THE UNIVERSITY *of* EDINBURGH

A FACTORIAL STUDY OF TWO AND THREE DIMENSIONAL SPACE TESTS

by

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T.R.

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CHAPTER I

THE PROBLEM

A major problem confronting educational administrators in England and Wales is that of classifying children for different kinds of secondary education. How to decide whether a child shall be educated in a Grammar, Technical or Modern School is the important question. According to the Norwood Committee, differentiation for types of secondary education should depend mainly upon the judgment of the teachers in the primary school.[1] But can we call upon the unaided judgment of teachers for such a vital decision, one which so greatly influences the child's future life?

In recent years, much thought has been given to the problem of selecting children for the Grammar school, and research studies have resulted in improved procedures of selection. A feature of such procedures has been the use of carefully standardised tests of intelligence and attainments. With the establishment of secondary technical schools, a demand has arisen for new tests to detect and assess technical aptitudes; and of the tests so far devised,

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1. Curriculum and Examinations in Secondary Schools.

Report of the Committee of the Secondary School Examinations Council (p.17) London, His Majesty's Stationery Office, 1943.

paper and pencil tests of spatial relations have shown promisingly high correlations with various criteria of technical ability. The present study is a contribution to research which has been carried out at Moray House relating to space tests and their predictive value for technical school subjects; it is concerned with the construction of a series of new space tests and a factorial analysis of the abilities which they measure. As a background to this study, a brief outline is given of the Moray House investigations as they concern our particular problem.

An experimental space test, containing approximately equal numbers of two and three dimensional items was produced in 1946, by J.T. Bain.[2] A subsequent factorial inquiry by W.G. Emmett[3] revealed that both two and three dimensional sections of the test are loaded with the same space factor, but that the three dimensional section has the higher loading. On the other hand, Z. Swanson[4] has found that the two dimensional section has the greater predictive value for various secondary school subjects such as geometry, science, woodwork and metalwork.

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2. J.T. Bain, The Construction of a Space Test. Unpublished B.Ed. Thesis, Moray House, Edinburgh University, 1946.
3. W.G. Emmett, "Evidence of a Space Factor at 11+ and Earlier," Brit. Journ. of Psychol. (Statistical Section), Vol. II, Part I (March 1949) p.9.
4. Z. Swanson, "Further Investigation of Moray House Space Test No. 1." Paper read at the meeting of the British Association for the Advancement of Science, Newcastle, September, 1949.

These findings suggest differences in the properties of two and three dimensional space tests, for if it is the space factor component which decides the predictive value of these tests, why has the two dimensional section greater predictive merit? A possible answer is that the ability to solve problems involving flat shapes and drawings differs somewhat from that required when solid objects have to be visualized and manipulated.

The main purpose of this study was to investigate the relative properties of two and three dimensional space tests. More specifically, it was an attempt to answer questions such as the following:-

Do two and three dimensional space tests measure the same ability? If not, what is the nature of the different factors underlying these tests and how are they related to more definitely established factors such as "g", the general factor of intelligence; "v", the verbal factor; and "n", the number factor? Alternately, if they measure the same ability, what is its nature and which type of test gives the better estimate of it? While of considerable theoretical interest these questions are of great practical importance for the construction of future space tests.

The Emergence of Specialized Abilities

The wisdom of the threefold classification of children into Grammar, Technical and Modern school

types at the age of eleven or twelve has been questioned by many.[5] It is not, they say, in keeping with the facts of child psychology. At this age, the child's intelligence is highly generalized and undifferentiated in structure. Specialized abilities and aptitudes are, they claim, as yet only vaguely discernible. On the other hand, others have presented plausible evidence that special abilities can be measured at age eleven and even earlier.[6] A study such as the present might be expected to throw further light on the extent to which special abilities are in fact evident at the transfer stage.

Criticism of the Tripartite System of Secondary Education

Now the question may be asked: "Even if it is found possible to classify children for different types of secondary schools, is such a classification desirable on educational grounds?" The Advisory Council on Education in Scotland has, for instance,

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5. Notably Sir Cyril Burt. See "The Education of the Young Adolescent: The Psychological Implications of the Norwood Report". British Journal of Educational Psychology, vol. XIII, Part III, Nov. 1943, pp. 126-140 and also "Symposium on the Selection of Pupils for Different Types of Secondary Schools" IX Conclusions, Brit.Journ. of Educ. Pshchology, Vol. XX, Part 1, Feb. 1950, pp. 1-10.
6. Evidence in support of this statement is considered in Chapter II, section 3, The Development of Spatial Ability. Infra p. 12.

stated[7]:-

"But even if the tripartite system where wholly feasible, is it educationally desirable? If education is much more than instruction, is in fact life and preparation for life, can it be wisdom thus to segregate the types from an early age. On the contrary, we hold that school becomes colourful, rich and rewarding just in proportion as the boy who reads Homer, the boy who makes wireless sets and the boy without marked aptitude for either are within its living unity a constant stimulus and supplement one to another."

By accepting this point of view, we in no way reduce the need for the present study. Quite apart from its theoretical interest, there exists a need for tests of special abilities even if only for purpose of diagnosis. A knowledge of the child's strengths and weaknesses is of particular value to the educator. Only with such knowledge can his methods of teaching be adapted to the child's aptitudes, interests and mental limitations. Furthermore, as Professor Dame Olive Wheeler[8] has said:

"if there is one thing that a child can do supremely well or very much better than he can do

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7. Secondary Education, A Report of the Advisory Council on Education in Scotland, p.31 Edinburgh, His Majesty's Stationery Office: 1947.
8. Olive A. Wheeler, The Adventure of Youth, p. 53. University of London Press, 1945.

anything else, its recognition may be absolutely necessary in encouraging self-respect and self-confidence, and may therefore be crucial to his general education."

It follows that only by recognising and training special abilities can boys and girls be enabled to achieve the highest degree of individual development of which they are capable, which, according to the late Sir Percy Nunn[9] should be the primary aim of all educational effort.

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9. Sir Percy Nunn, Education: Its Data and First Principles, p.5. London: Edward Arnold and Co., Third Edition, 1945.

CHAPTER II.

REVIEW OF PREVIOUS RESEARCH WORK.

(1) The Nature of Technical Ability.

Consideration will first be given to the nature of technical ability and various factors related to it.

Technical ability is a broad, general term used to denote ability in any branch of art or science wherein emphasis is placed on practical skill, proficiency in the manipulation of tools and instruments, and ability in constructional work of all kinds. Factorial studies relating to various aspects of the ability have been made by a number of investigators. These studies have established the existence of three important group factors - one underlying mechanical aptitude tests, one underlying performance tests and one underlying tests of spatial relations. The factors are not entirely independent for they overlap to a certain extent.

The presence of a group factor underlying tests in which the subject is required to solve problems relating to various mechanical diagrams and models has been demonstrated by Cox.[10] This factor he

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10. J.W. Cox, Mechanical Aptitude - its Existence, Nature and Measurement, 1928.

referred to as "mechanical aptitude" and represented by the letter "m".

A more recent study of mechanical aptitude has been made by Williams[11]. He distinguished two related factors - a spatial factor and a mechanical factor. The former appeared to be mainly perceptual or receptive in nature and the latter constructive or executive. This association of spatial and mechanical factors is in accordance with the findings of previous investigators. Slater[12], for instance, put forward the view that mechanical ability might be explained in terms of general intelligence and spatial judgment; while Paterson and his colleagues[13] found that space tests and mechanical assembly tests were equally valid measures of mechanical ability.

Alexander[14] demonstrated the presence of a factor F which plays a part, over and above g, in performance tests. He called it the "practical factor". Practical ability, he deduced, could be explained in terms of g and F. His study indicates that mechanical ability as measured by Cox's tests is not the same as

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11. H.S. Williams, "The Measurement and Maturation of Mechanical Aptitude", Proc. 12th Internat. Congress of Psych., Edinburgh, 1948 (Under publication)
12. P. Slater, "Some Group tests of Spatial Judgment or Practical Aoility", Occupational Psychology, Vol. XIV, No. 1, Jan. 1940, p. 40.
13. D.S. Paterson, et al., Minnesota Tests of Mechanical Ability. Minneapolis, 1930.
14. W.P. Alexander, "Intelligence, Concrete and Abstract", British Journal of Psychology, Monograph Supplement No. XIX, 1935.

practical ability, but that the two abilities are closely related in that certain tests of the two groups show relatively high intercorrelations.

An investigation of sex differences in tests of mechanical ability led Koussy[15] to consider the possible existence of a specialized ability in the perception and mental manipulation of spatial material. After accounting for the influence of "g" on the intercorrelations of a large battery of tests, he discovered a significant group factor present in some but not all of his space tests. On the basis of introspective evidence, Koussy interpreted this factor as "the ability to obtain and the facility for utilizing visual spatial imagery". Other workers, notably Thurstone[16], have confirmed the existence of this factor. Koussy denotes it by the letter K, Thurstone by the letter S.

Now the tests designed to measure F and K are closely similar in that they both require the subject to manipulate objects in space. In the former type of test, manipulation may be carried out manually; but in the latter, it must be done by means of mental images. Moreover, several of the tests shown to be loaded with the space factor are, in fact, paper and pencil versions of tests used to measure F.

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15. A.A.H. El Koussy, "The Visual Perception of Space," British Journal of Psychology, Monograph Supplement No. XX, 1935.
16. L.L. Thurstone, Primary Mental Abilities. Psychometric Monograph, No. 1, Chicago, 1938.

Reasoning along these lines, Price[17] administered both kinds of tests to a group of students and found evidence for the identity of F and K. More recently, in a study with children aged between eleven and thirteen years, Dempster[18] has arrived at the same conclusion. On the other hand, Drew[19] applied both performance and space tests to four groups of boys aged eleven, twelve, thirteen and sixteen and apparently demonstrated the independence of F and K. His data, however, were re-analysed by Emmett,[20] and his results appear to support the findings of Dempster and Price. Perhaps the most satisfactory view of the relationship between F and K, pending further studies, is that of Burt[21] who regards them as sub-factors in a fairly broad group factor of practical ability.

This view is in agreement with that of Vernon,[22] who in a survey of studies made in the Armed Services

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17. E.J.J. Price, "The Nature of the Practical Factor," British Journal of Psychology, Vol.XXX, 1940, pp. 341-351.
18. J.J.B. Dempster, "Symposium on Selecting Pupils for Different Types of Secondary Schools," Brit. Journ. of Educ. Psych. Vol. XVIII, 1948, pp. 121-130.
19. L.J. Drew, "The Measurement of Technical Ability", Occupational Psychology, Vol.XXI, No.34, 1947, pp. 34-48.
20. Emmett. op. cit., p. 12.
21. Sir Cyril Burt, "Symposium on the Selection of Pupils for Different Types of Secondary Schools", IX-Conclusions. Brit. Journ. of Educ. Psych., Vol. XX Part 1., Feb. 1950, p. 3.
22. P.E. Vernon, "The Structure of Practical Abilities", Occupational Psychology, Vol. XXIII, No. 2, April 1949, p. 94.

concluded:

". . . a rather general practical or k:m type of ability does exist, but it is so amorphous and heterogeneous that it would seem to be not so much a positive ability as an aggregate of all non-symbolic capacities and of abilities unaffected by primary schooling. It is hardly possible in our present state of knowledge to identify the underlying core or essential psychological nature of the factor. But we do know that not only mechanical and spatial, but physical and manual, and some non-verbal g, perceptual and performance tests, together with practical occupational abilities have something in common over and above g."

(2) The Predictive Value of Space Tests for Various Kinds of Technical Work.

There have been a number of direct investigations of the predictive value of space tests for various kinds of technical work. Findings are, on the whole, quite favourable.

Shuttleworth[23] found significant correlations between space test performance and both teachers' and employers' estimates of mechanical ability.

In the engineering industry, Holliday[24] found

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23. C.W. Shuttleworth, "Tests of Technical Aptitude", Occupational Psychology, Vol. XVI, Part 4. Oct. 1942, p. 175.
24. F. Holliday, A series of four articles on the selection of apprentices in the engineering industry, in Occupational Psychology, Vol. XIV, Apr. 1940 p. 69; Vol. XV, Oct. 1941 p. 173; Vol. XVI, Jan. 1942, p. 1. and Vol. XVII, Oct. 1943, p. 168.

that the selection of apprentices could be improved and wastage considerably reduced by the use of space tests. He reports satisfactory correlations with assessments of technical proficiency after an interval of four years.

Reasonably high correlations of space test results with practical school subjects for a group of boys aged thirteen have been obtained by Macfarlane Smith.[25]

More recently, Swanson[26] has given the results of a follow-up study of pupils in an English Grammar school and other in a Modern Secondary school, tested with the Moray House space test. For the grammar school pupils fairly high correlations with school success in Geometry, Science and Art were obtained, and for the modern school pupils, with Woodwork and Metal-work.

(3) The Development of Spatial Ability.

As already indicated, doubts have been expressed as to whether the aptitudes which make for success in technical work are sufficiently mature at the age of eleven. These doubts arise from the apparently negative findings of several investigators in their attempts to isolate factors such as F and K at this

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25. I. Macfarlane Smith, "Measurement of Spatial Ability in School Pupils", Occ. Psych., Vol. XXII, 1948, pp. 150-159.
26. Swanson. op. cit.

age. Slater,[27] for example, using several established space tests found no evidence of a space factor either at age eleven or thirteen. He concluded that these tests do not differentiate the ability before fourteen at least. Drew, also, in the study previously mentioned,[28] reported the absence of K at age eleven and twelve, although it appeared possible to measure F at eleven.

The absence of a space factor in Slater's work may be attributed to his method of analysis, for Adcock[29] in a re-analysis of Slater's data by three different methods claims to have demonstrated its presence. In a reply to Adcock, however, Slater[30] defends his position, claiming the adequacy of his solution in terms of the factors "g" and "v" only. He critizes Adcock's solutions in that they attribute K loadings to one or more of the non-verbal "g" tests. Emmett[31] would seem to have strengthened the position of Slater's critics. In a re-analysis by Lawley's Method of Maximum Likelihood, which provides a reliable test for the significance of factors extracted,

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27. P. Slater, Two articles in Occupational Psychology, Vol. XV, Jan. 1941, p.10 and Vol. XVII, July 1943, p. 139.
28. Drew, op. cit.
29. C. Adcock, "A Re-analysis of Slater's Spatial Judgment Research", Occ. Psych., Vol. XXII, No.4, 1948, p. 213-216.
30. P. Slater, "Mr Slater replies to Dr Adcock", Occ. Psych., Vol. XXIII, No. 2, Apr. 1949, p. 127.
31. Emmett, Op. Cit., p. 14.

he has demonstrated the significance of a factor in addition to "g" and "v," and shown that this factor may be taken to be K. Furthermore he gives an explanation of the presence of an appreciable K loading in one of the non-verbal "g" tests.

Of particular interest, on account of the above disagreements, are the factorial studies of Thurstone. Having demonstrated the existence of a space factor working with students,[32] he designed space tests suitable for children aged between twelve and fifteen and again isolated a space factor.[33] Later he administered a battery of seventy tests to two hundred children aged between five and six years.[34] The tests included tests of intelligence, tests of both arithmetic and reading readiness, and also several simple space tests. The important result of this experiment was not only the discovery of a space factor, but also many of the factors which had been isolated in the studies with older children and students. Thurstone considers the space factor to be of fundamental importance in the child's intelligence and makes the

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32. L.L. Thurstone, Primary Mental Abilities, Chicago, 1938.
33. L.L. and T.G. Thurstone, Factorial Studies of Intelligence. Psychometric Monograph, No. 2, Chicago, 1941.
34. L.L. and T.G. Thurstone, Examiner Manual for the Tests of Primary Mental Abilities. p. ii, Chicago, 1946.

following comment:-[35]

"The fact that young children have had no specific training in the factor suggest that it is fundamental in the child's intelligence and that opportunity to make use of it should be amply provided in the early school experience of the child".

It would appear therefore that provided suitable tests can be devised it is possible to detect a space factor even as early as age five.

The question of the relationship between the space factor isolated at an early stage in the child's mental development and that isolated later would appear to have been answered by Robertson.[36] He found that the spatial component of the Moray House Seven Plus Picture Test is substantially the same as that measured by the Eleven Plus Space Test.

(4) Two and Three Dimensional Space Tests.

So far in our discussion of space tests, no distinction has been made between two and three-dimensional problems. The tests utilized by Koussy in his investigation referred to above[37] all involve two dimensional figures and drawings. Now the question arises: Can a distinction be made between the

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35. Ibid., p. iii.
36. R. Robertson, The Space Factor at Seven Plus and Twelve Plus. Unpublished B.Ed., Thesis, Moray House, Edinburgh University, 1949.
37. Koussy, op. cit.

ability required to visualize flat shapes and figures and that in which solid imagery is involved? Some consideration to this and related problems was given by Thurstone in his Primary Mental Ability study[38] His battery contained both types of tests. In general his finding was that two and three dimensional tests are loaded with the same factor. He obtained no real evidence as to the superiority of either type of test as a measure of the space factor. The tests with highest loadings in the factor were:[39]

(a) Cubes	.626	(c) Lozenges B	.633
(b) Flags	.636	(d) Pursuit	.584
		and(e) Surface Development	.551

Of these(a) and(e) clearly involve three dimensional imagery, and the rest two dimensional imagery.

Quite recently, Koussy[40] has made a further inquiry into the nature of the space factor in which he has concentrated on its three dimensional aspect. On the basis of a re-analysis of Thurstone's Primary Mental Ability data relating to space tests, he claims that, on the whole, three dimensional tests provide a better measure of the space factor. His evidence on this point, however, is none too convincing.

In a fresh investigation, Koussy administered a battery containing two and three dimensional space

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38. L.L. Thurstone, Primary Mental Abilities, p. 11.
39. Ibid., p. 79.
40. A.A.H. El. Koussy, "A Further Examination of the K Factor", Proc. 12th Internat. Congress of Psych., Edinburgh, 1948 (Under publication).

tests together with tests of mechanical ability and intelligence to a group of seventy-one boys aged fourteen and a half. He arrived at the following conclusion:-

"The deciding character does not seem to be whether the test is two dimensional or three dimensional, but that it calls for the ability to carry and manipulate the spatial material in the 'mind'."

It may be remarked, however, that many of the tests used by Koussy were seemingly unsuitable in that the abilities which they measured were largely specific, for the mean communality of the battery was barely .40. Furthermore, out of 190 correlation coefficients 102 were insignificantly different from zero, the mean correlation coefficient being only .20.

The explanation, given by Koussy, of the low correlations, was that there was some fault in the printing of his tests.

A claim to have isolated separate spatial factors underlying the two and three dimensional parts of the Moray House Space test was made by R. Robertson.[41] However, in view of the fact that, statistically speaking, the intercorrelations of both parts of the space test with each of the other tests in his battery are insignificantly different from each other, it is doubtful whether his claim can be substantiated.

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41. Robertson, op. cit.

We may conclude, therefore, that as far as previous researches are concerned, attempts to resolve the space factor into separate two and three dimensional components have produced negative results. Nevertheless, the Moray House investigations referred to in Chapter I[42] indicate that two and three dimensional space tests do possess different properties and it was to investigate these, with a series of new space tests, that the present study was undertaken.

42. Supra p. 2.

CHAPTER III.

OUTLINE OF THE PRESENT RESEARCH.

(1) Plan of the Test Battery.

As already indicated, we are concerned in this study with the existence and nature of specialized factors of intelligence measurable at the transfer stage, and especially with those factors underlying two and three dimensional space tests. Now it is for the solution of such problems that methods of factorial analysis have been developed. There being several factorial methods available, our first task is to decide which particular method to adopt. Fortunately, the various methods have been shown to yield much the same results psychologically, and so our choice is a somewhat arbitrary one. There are, however, certain advantages and disadvantages associated with each particular method and these need to be considered carefully. It was decided to use Thurstone's centroid analysis with subsequent rotation to "simple structure" and to plan the study accordingly. Detailed consideration of the various advantages and disadvantages of this method and of possible criticisms will be given in Chapter VI.

Having decided upon the factorial method to be followed, it is necessary to consider what set of test variables are relevant to our problem. Firstly, we require both two and three dimensional space tests

and there must be at least three of each kind for a satisfactory analysis. Secondly, we require a number of reference tests, since we cannot be sure what the space tests are measuring if we do not consider them in relation to tests of established factorial composition. The tests normally used at the transfer stage may be classified as follows:-

(i) Verbal tests of intelligence

(ii) Non-verbal tests of intelligence

(iii) Arithmetic tests

(iv) English tests

and the factors usually defined by these are "g", "v" and "n". It was decided that a reference battery containing two each of these tests would be adequate, although three each would have been preferable. An experiment on such a scale, however, was not feasible.

In any factorial experiment, the interpretation of results is considerable aided, when tests are used which are homogeneous in content and of low complexity (i.e. involve few factors). This latter requirement is of particular importance when "simple structure" is aimed for. Since most available tests do not satisfy these two requirements, it was decided to undertake the construction of the tests used in the experiment. There was one exception in that the Jenkins' Scale of Non-Verbal Ability was used as one of the reference tests.

The Space Tests.

In previous studies with eleven-year olds or younger children, two dimensional space tests have mostly been used. The reason for this appears to be that three dimensional space tests are, on the whole, relatively more difficult. This fact, together with our decision to use only homogeneous test material, made the task of devising suitable three dimensional tests somewhat difficult. Appendix IV contains copies of the original versions of the space tests. These were first of all given a preliminary try-out, and as the result of a careful item analysis unsuitable items were rejected and revised versions of the tests produced. One promising three dimensional test unfortunately proved too difficult and could not be used. A copy of this test (Space 7/R) is contained in Appendix III, since it may be of value in future investigations with older children or adults. Appendices I and V contain the revised versions of the space tests and the answer pattern data relating to the original tests, respectively.

The Reference Tests.

In order to select the most suitable reference tests, a careful study was first of all made of the various sub-tests of Moray House Intelligence, English and Arithmetic tests. As a result, a Synonyms test and a Word Formation test (both based on Moray House

English tests) were constructed in the hope of establishing a verbal factor. In addition, two arithmetic tests (based on Moray House arithmetic tests) were devised with the object of isolating a number factor. From the sub-tests of Moray House Intelligence tests, a Verbal Analogies test and a Word Series test were constructed. Since these tests involve verbal comprehension, it was expected that they would involve the verbal factor in addition to "g". The Jenkins' test and a new Number and Letter Series test were included as non-verbal intelligence tests. Interest centres in the Number and Letter Series test since in the factorial studies of Thurstone this test has yielded a Reasoning factor. The possibility of isolating such a factor in this study must not be overlooked.

General Considerations.

In undertaking the construction of a large number of tests such as was envisaged in this study, there are certain general considerations which must be born in mind. These will be outlined below.

(i) Reliability of Tests.

Reliability sets an upper limit which the communality of a test (and hence the sum of squares of its common factor loadings) cannot exceed.[43] It

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43. L.L. Thurstone, Multiple-Factor Analysis, p.84. Chicago, 1947.

follows, therefore, that in order to obtain more highly significant loadings, we must make our tests reliable. Since the reliability of a test increases with increasing length, it is desirable to use fairly long tests. On the other hand, there is a danger with homogeneous test material that the examinees might lose interest when working a large number of similar items. As a consequence, it is necessary to effect a satisfactory compromise. In general, many previous studies seem to have erred on the side of too few, rather than too many items.

(ii) Difficulty and Discrimination.

If questions are too easy, one has to discriminate amongst the examinees by reducing the time allowed for the test. While this is often desirable with attainment tests it is unsatisfactory in an experiment such as the present; for if all tests in the battery are speeded, a significant component, attributable to speed, is added to the general factor underlying the tests, and consequently we magnify the importance of this factor in relation to the group factors. For this reason it is more desirable to discriminate by difficulty of item rather than by speed. We must not, however, make items too difficult, otherwise we defeat our object which is to obtain good discrimination. As a general rule, items which are answered correctly by more than 80% of the examinees

are considered too easy, and items which are answered correctly by less than 20% too difficult. As all the tests used in the experiment were previously subjected to a careful item analysis they could be expected to give good discrimination.

Practice tests.

Each test was preceded by a short practice test, the purpose of which was to ensure that every child understood what he had to do and how to record his answers. The practice tests were not marked.

Details Relating to the Test Battery.

Table I gives the names of the tests used in the experiment, together with details of the number of items they contain and the time allowances

TABLE I.

THE TEST BATTERY

No.	Name of Test	Time (in Minutes)		Number of Items
		Practice Test	Test Proper	
1.	Space 1/R	15	45	80
2.	Space 2/R	15	40	86
3.	Space 3/R	15	40	70
4.	Space 4/R	15	30	100
5.	Space 5/R	15	45	60
6.	Space 6/R	20	30	113
7.	Synonyms	10	20	80
8.	Word Formation	10	30	80
9.	Verbal Analogies	10	25	80
10.	No. & Letter Series	10	30	88
11.	Word Series	10	20	80
12.	Non-verb. Intell., Jenkins	-	30	85
13.	Mechanical Arithmetic	10	45	80
14.	Problem Arithmetic	10	45	74

It will be seen that the total number of items administered to each pupil was 1156, and that the total testing time, excluding practice tests, was almost 8 hours. The testing programme extended over a fortnight. Details of the time-table are given in Section 3 of this chapter.

(2) The Experimental Groups.

In a factorial study we endeavour to isolate the factors, real or apparent, which may be considered to cause or explain individual differences among persons. In our particular study, we wish to isolate those factors which account for individual differences in the test performances of eleven-year old children. It follows, therefore, that the composition of our experimental group is a matter of some importance, since observed individual differences must depend on the nature of the group studied. As a consequence it is necessary to consider carefully the requirements of the experimental group.

Requirements of the Experimental Group in a Factorial Experiment.

(i) the experimental group should, as far as possible, constitute a representative and unbiased sample of the particular population under consideration.

(ii) the number of individuals in the sample should be large in order to minimize sampling error.

(iii) on account of sex differences associated with certain tests, results for boys and girls should

be analysed separately.

(iv) Age should be held constant. Since it is impracticable to test children all of exactly the same age, it is desirable to eliminate, by statistical means, the influence of age differences.

In designing our experiment careful attention was paid to each of the above points.

In order to obtain a representative sample of children from the various social and economic sections of the community, over 500 pupils from 14 different primary schools in the City of Edinburgh were tested. This number was considered large enough to allow for wastage due to absence; it being decided to include in the experimental group only those children who took all tests. The particular advantage of this decision is that all inter-test correlations relate to the same number of cases. As a result of an approximately 18% wastage, the experimental group consisted of 229 girls and 206 boys. The distribution of these pupils among the 14 schools is shown in Table II.

TABLE II.

THE COMPOSITION OF THE EXPERIMENTAL GROUP.

School	Number of Pupils		
	Boys	Girls	Total
A	11	16	27
B	8	12	20
C	12	16	28
D	9	12	21
E	17	21	38
F	9	13	22
G - Class 1	16	21	37
- Class 2	17	12	29
H	14	21	35
I	17	12	29
J	13	12	25
K	16	16	32
L	18	12	30
M	18	19	37
N	11	14	25
Total	206	229	435

Owing to the presence of a number of both advanced as well as retarded children in the classes tested, the age range is fairly wide. However, since it was decided to remove the effect of age, from the results, by statistical means this is not serious. Figures 1 and 2 give details relating to the ages of the pupils.

It will be seen that the groups are roughly parallel.

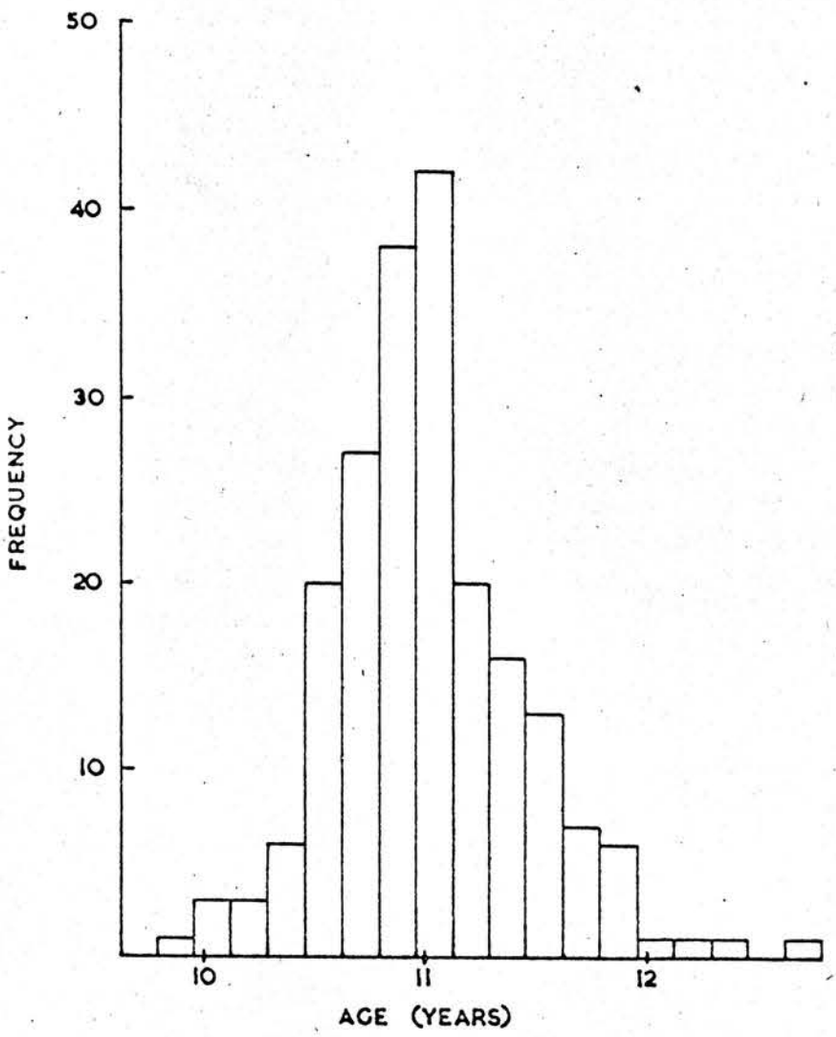


Fig. 1 HISTOGRAM SHOWING AGE DISTRIBUTION — BOYS

MEAN = 11 YEARS 0·1 MONTHS σ = 5·15 MONTHS

PERCENTAGE BETWEEN 10 YEARS 6 MONTHS
& 11 YEARS 5 MONTHS = 79·13

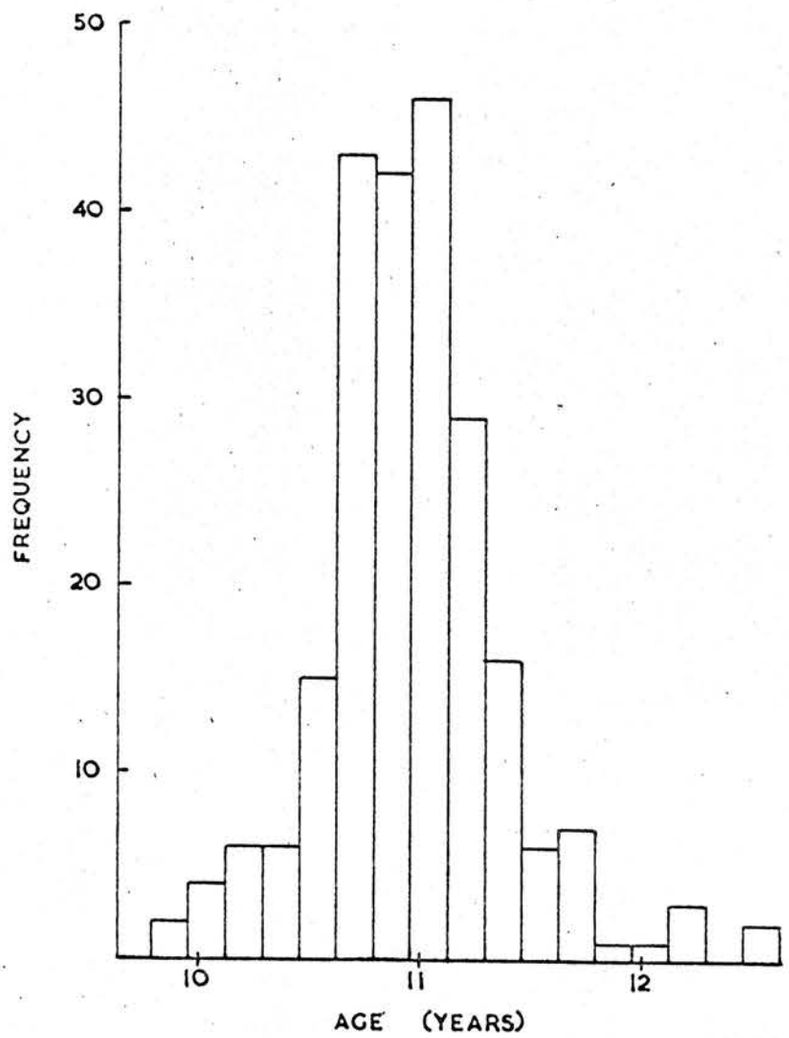


Fig. 2 HISTOGRAM SHOWING AGE DISTRIBUTION — GIRLS

MEAN = 10 YEARS 11·6 MONTHS σ = 5·04 MONTHS

PERCENTAGE BETWEEN 10 YEARS 6 MONTHS
& 11 YEARS 5 MONTHS = 83·41

(3) Administrative Arrangements.

(i) Administration of the tests.

The tests were administered by students of Moray House Training College who had been carefully instructed in the test procedure. Class teachers in the schools where the testing was carried out also gave valuable assistance. Appendix II contains a copy of the instruction issued to the testers.

The tests were administered in the forenoon according to the time-table shown in Table III.

TABLE III.

TIME-TABLE FOR THE ADMINISTRATION OF THE TESTS.

D A Y	T E S T
Mon. May 9th 1949	Space 2/R
Tues. May 10th "	Space 6/R Word Series
Wed. May 11th "	Mechanical Arithmetic
Thurs. May 12th "	Number and Letter Series Verbal Analogies
Fri. May 13th "	Space 1/R
Mon. May 16th "	Space 3/R
Tues. May 17th "	Space 4/R Synonyms
Wed. May 18th "	Problem Arithmetic
Thurs. May 19th "	Word Formation Non-Verb. Intell., Jenkins'
Fri. May 20th "	Space 5/R

In drawing up this time-table an attempt was made to place the tests in the approximate order of difficulty.

(ii) Marking the tests.

In all there were over 7,000 scripts. These were corrected by students. A random sample of approximately 5% of the scripts were checked by the writer with a view to estimating the extent of marking error. It was found that the only source of serious error was in the addition of scores on the title page. Several scripts were found to contain errors in the tens column. A check to eliminate such errors was therefore made for all scripts.

CHAPTER IV.

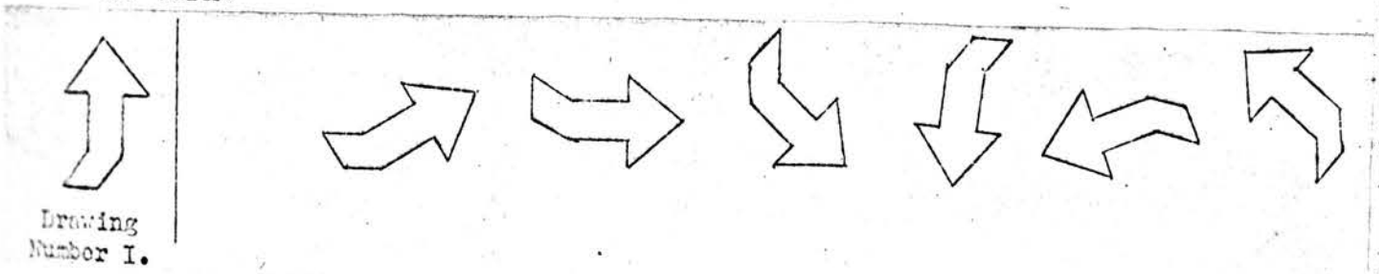
DESCRIPTION OF THE TESTS USED IN THE EXPERIMENT.

The tests will be described in the order in which they are listed in Table I. With the exception of the Jenkins' "Scale of Non-Verbal Ability", each test was preceded by a short practice test. These practice tests are reproduced here as a sample of the kind of items contained in each test. The Jenkins' "Scale" is illustrated by sample items taken from the test proper. Appendix I (separately bound) contains a complete set of the tests used in the experiment.

Space Test 1/R.

Look at Drawing Number I in the row below.

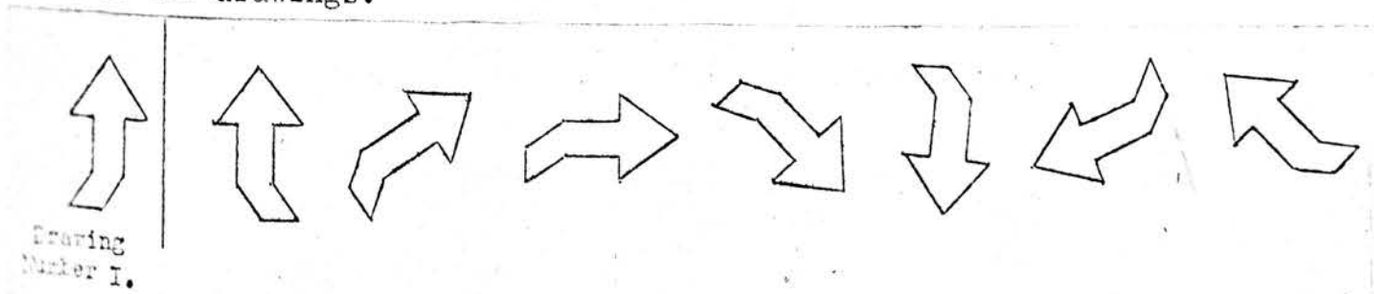
Suppose we move it along the row and turn it round on the page. We can fit it exactly on top of each drawing, in turn.



Drawing Number I.

Look at Drawing Number I in the row below, it is the same as before.

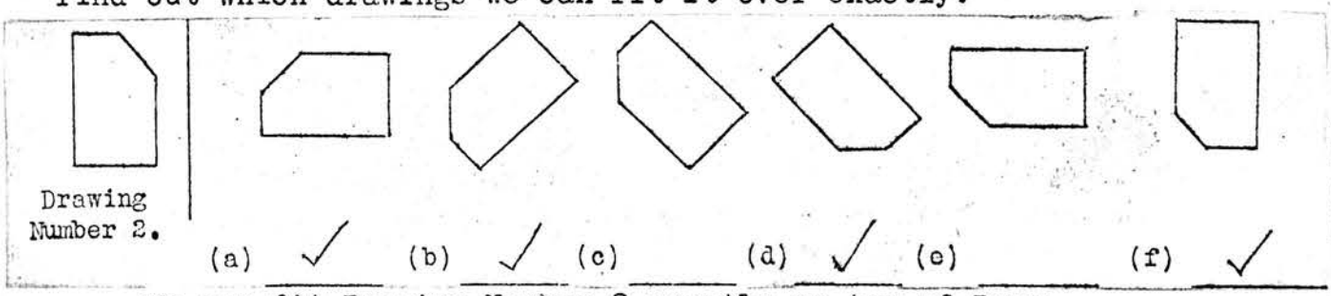
This time, by moving it along the row and turning it round on the page, we <u>CANNOT</u> fit it exactly on top of any of the drawings.



Drawing Number I.

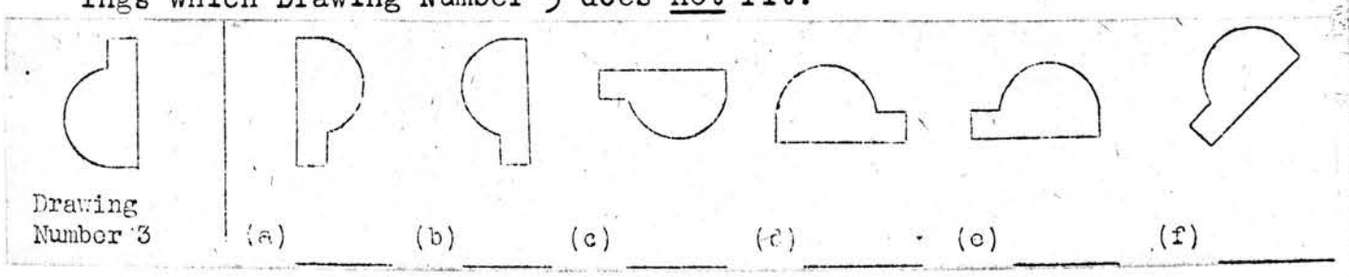
Now look at the next row of drawings.

If we move Drawing Number 2 along the row and turn it round on the page, we can fit it exactly on top of <u>some</u> of the drawings, but not on others. You have to find out which drawings we can fit it over exactly.



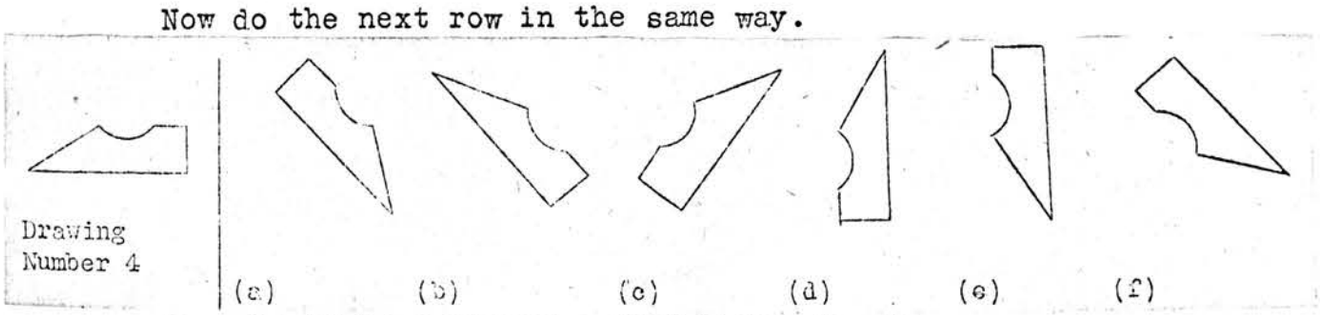
We can fit Drawing Number 2 exactly on top of Drawings (a), (b), (d), and (f). So we have placed a tick (✓) on the line under each of them.

In the row of drawings below, place a tick (✓) under <u>each</u> drawing which Drawing Number 3 will fit when turned round on the page. Do <u>not</u> place a tick under those drawings which Drawing Number 3 does <u>not</u> fit.



You should have placed a tick under drawings (a), (c), and (d).

Now do the next row in the same way.

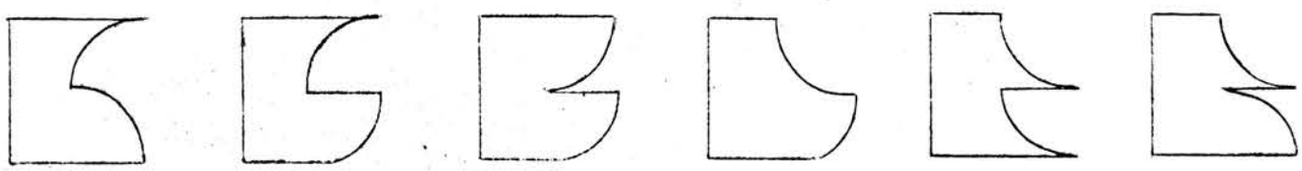


You should have placed a tick under drawings (b), (e), and (f).

The test proper contained 40 rows of drawings. In order to minimize the effect of guessing, drawings (a), (b), and (c) in each row were scored as one item and drawings (d), (e) and (f) as another. Thus, in effect, the test contained 80 items.

2. Space Test 2/R.

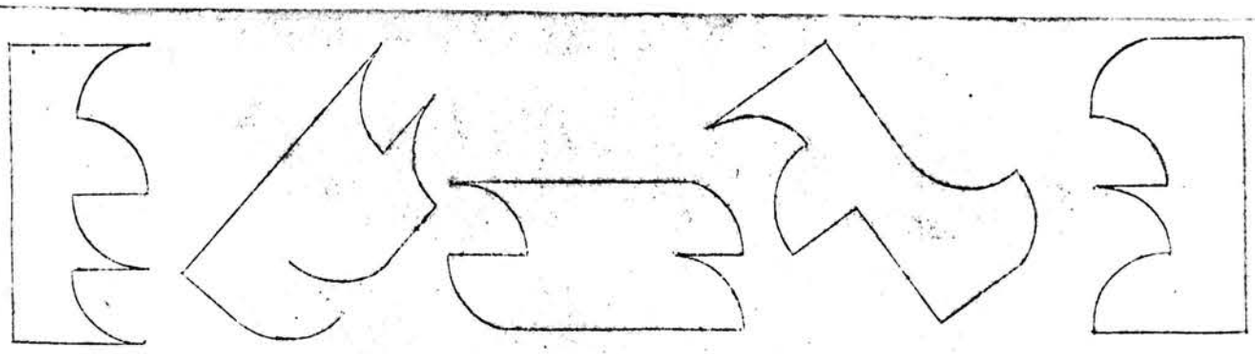
In the row below there are six different shapes, lettered A, B, C, D, E and F.



In the next row, there are some drawings which have been made by fitting together <u>two</u> of the shapes A,B,C,D, E and F.

You have to find out which <u>two</u> shapes have been fitted together in each drawing, and write their letters on the line underneath.

The first question has been done for you. See if you can do the others.



(I) A, E (2) (3) (4) (5)

Notice that some of the shapes have been turned over.

Now check your answers. You should have placed two letters under each drawing.

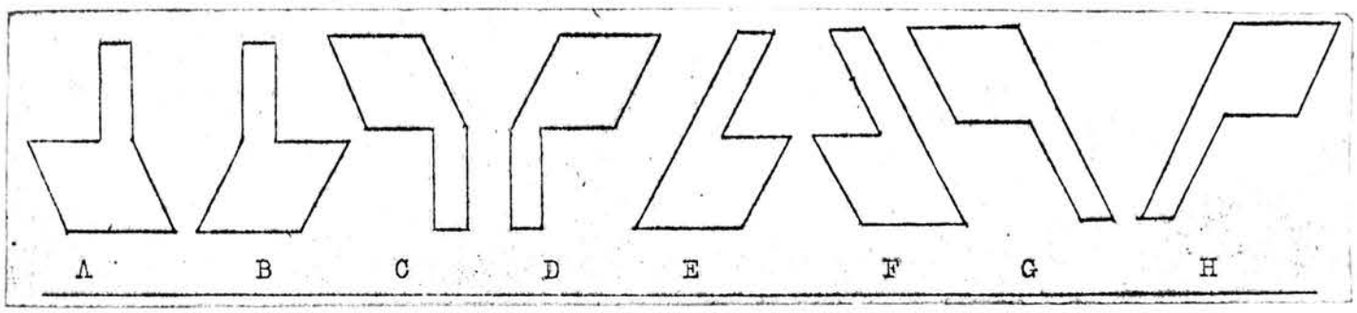
The answers are:- (I) A, E. (2) C, E. (3) B, C. (4) A, D. (5) A, D.

The order of the letters does not matter.

The test proper contained 86 items.

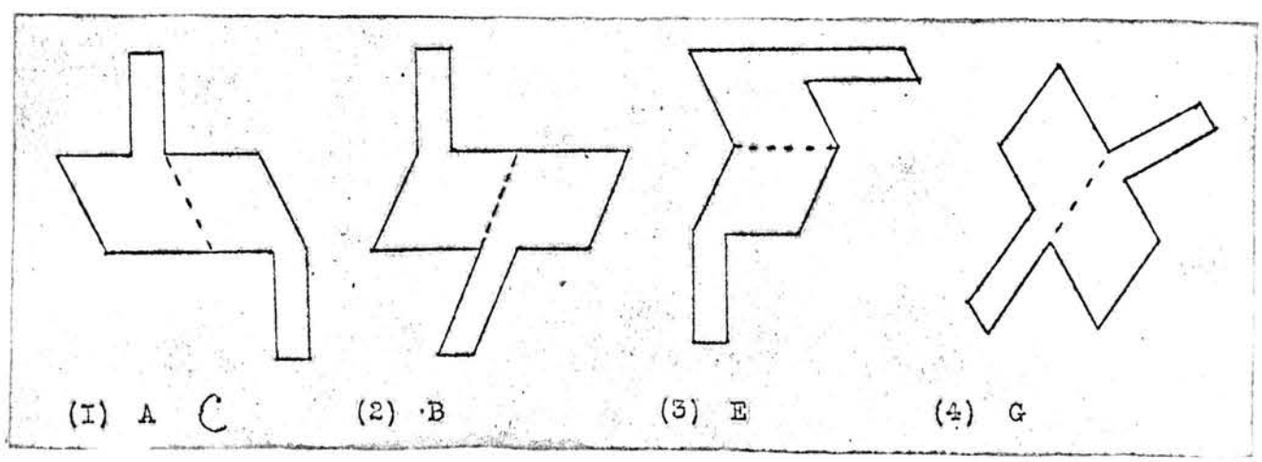
3. Space Test 3/R.

In the row below there are eight different shapes, lettered A, B, C, D, E, F, G, and H.



Notice the difference between shapes A and B; C and D; E and F; G and H.

By moving the shapes on the page, we can fit two together and make a new drawing. In the next row, there are some drawings which have been made in this way.

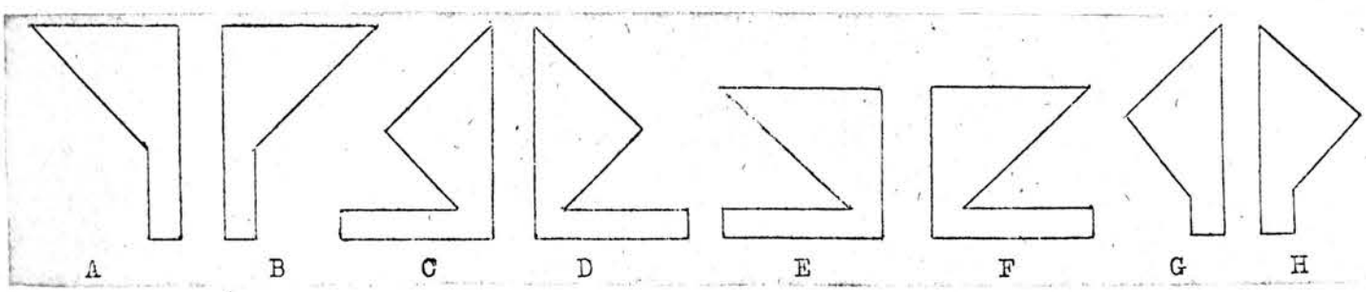


In each drawing you are told what one of the shapes is, and you have to find the other and write its letter underneath.

The first question has been done for you. See if you can do the others.

Correct your answers. You should have written the letter H under drawing Number 2; D under drawing Number 3; and C under drawing Number 4.

The test proper contained 70 items, 30 of which were based on the premise shapes given in the practice test and 40 on the following:-



4. Space Test 4/R.

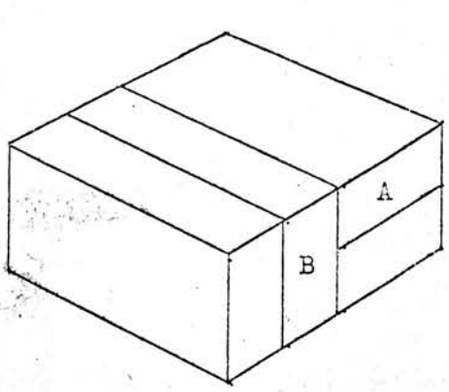
The drawings below show models which have been built with blocks. All the blocks are of the same shape and size. Notice that some of the blocks have been lettered.

You have to find out how many blocks are touched by each of the lettered blocks and write the answers in the blank spaces underneath.

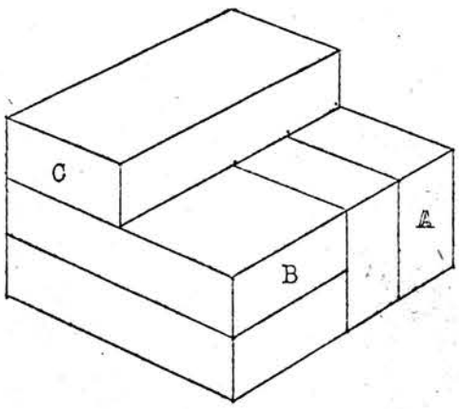
For example, in the first model, block A touches two other blocks; and so we have written 2, below A, in the blank space underneath the first drawing.

See if you can find out how many blocks are touched by block B, in the same model. Write the answer, below B, in the blank space underneath.

Now do the same for each of the lettered blocks in the second model. Make sure that you count all blocks touched by each lettered block.



A	B
2	



A	B	C

Correct your answers. You should have:-

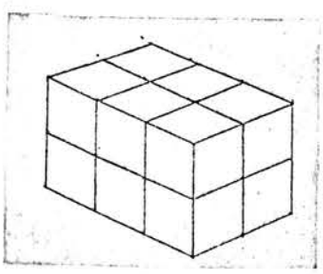
A	B
2	3

and

A	B	C
2	3	3

The test proper contained 100 items.

5. Space Test 5/R.



Look at the drawing at the top of the page. It shows an oblong block made of small cubes.

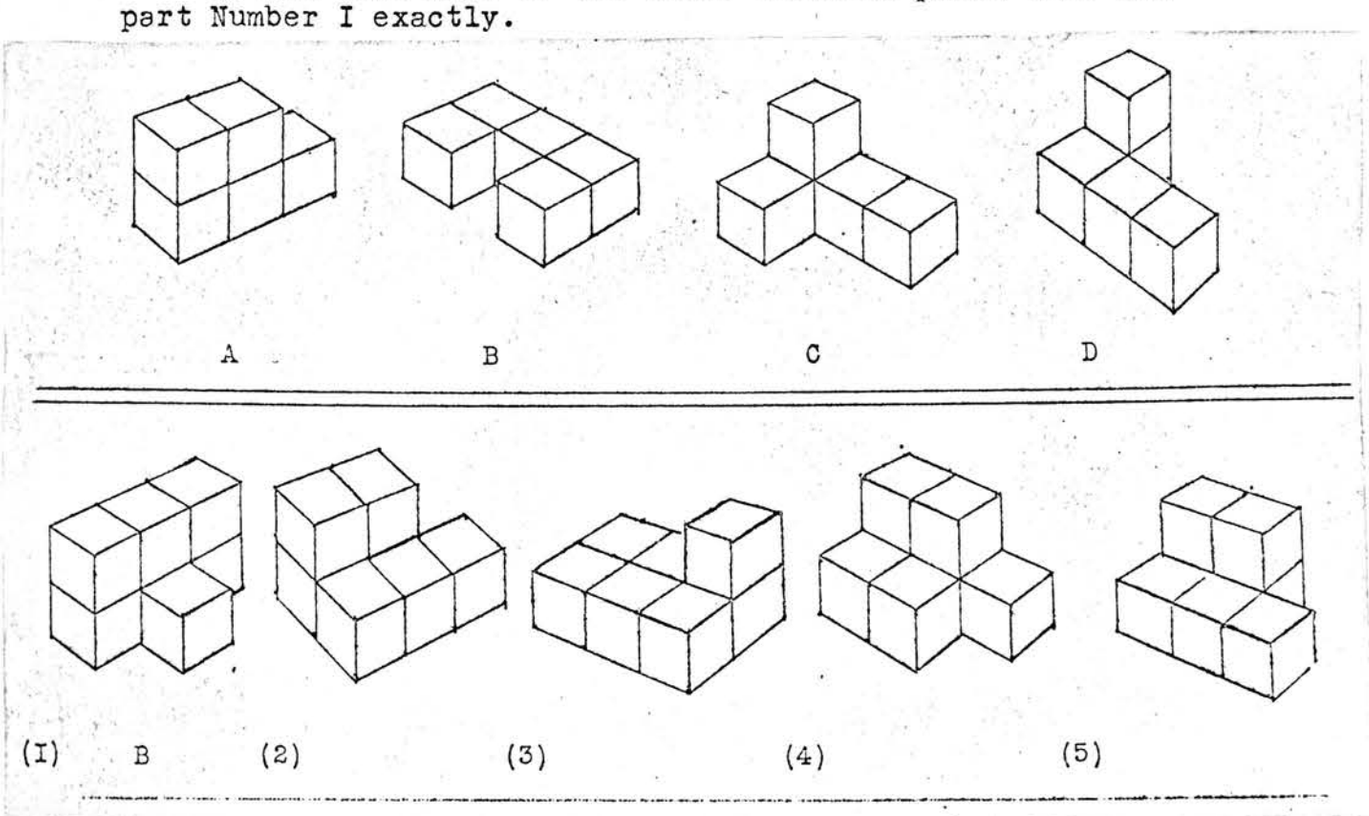
Now look at the drawings below. They show parts of an oblong block like the one shown above. Notice that the four parts <u>above</u> the double line are lettered A, B, C and D,

while the five parts <u>below</u> the double line are numbered I, 2, 3, 4 and 5.

You have to find out which of the lettered parts will fit <u>exactly</u> each of the numbered parts to make an oblong block like that at the top of the page.

For example, part B will fit exactly part Number I, and so we have written the letter B on the line underneath.

Notice that none of the other lettered parts will fit part Number I exactly.



For each of the numbered parts 2, 3, 4 and 5, write on the line underneath the letter of the part needed to make an oblong block like that shown at the top of the page.

The parts may be turned over into any position but they must fit exactly.

A lettered part may be used more than once.

Correct your answers. You should have:-

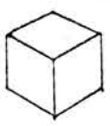
(2) D. (3) A. (4) C. (5) D.

The test proper contained 60 items.

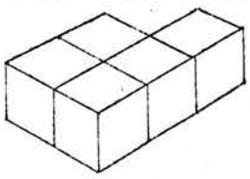
6. Space Test 6/R.

Look at drawing Number I below. It shows a cube. A cube has <u>six</u> sides or faces.

Now look at drawing Number 2. It shows a model which has been made by gluing together five cubes.



Drawing Number I.



Drawing Number 2.

I	2	3	4	5
0	1			

Suppose the model in drawing Number 2 has been painted on all sides <u>except</u> the bottom. You have to find out how many of its cubes have paint on <u>one</u> face only; how many have paint on two faces only; and so on.

For example, in the model shown in drawing Number 2, there are no cubes having paint on <u>one</u> face only, and so we have placed 0 in column I at the side of the model. There is one cube having paint on <u>two</u> faces only, and so we have placed I in column 2 at the side of the model.

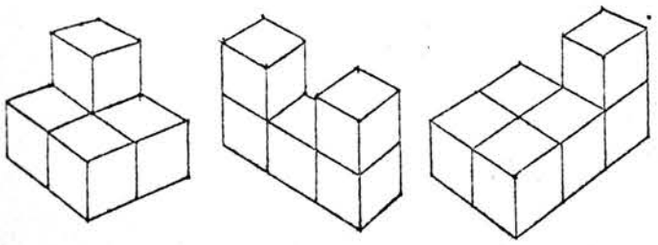
See if you can find out how many cubes there are having paint on <u>three</u> faces only. Write the answer in column 3 at the side of the model.

Do the same for cubes having paint on <u>four</u> faces only and for cubes having paint on <u>five</u> faces only.

Correct your answers. You should have written 3 in column 3; I in column 4; and 0 in column 5.

For each of the models shown in drawings 3, 4, and 5 below, write in column I at the side to show how many cubes have paint on one face; in column 2 to show how many cubes have paint on two faces; and so on.

Remember that the models are painted on all sides <u>except</u> the bottom.



(3) (4) (5)

	1	2	3	4	5
(3)					
(4)					
(5)					

Correct your answers. You should have:-

	1	2	3	4	5
(3)	0	1	3	0	1
(4)	0	0	3	0	2
(5)	0	1	4	0	1

The test proper contained 113 items.

7. Synonyms Test.

In this test, you have to underline in the brackets the word which means most nearly the SAME as the word in capital letters.

Here is an example:

Although he has done me harm, I shall PARDON him.

(punish / love / reward / <u>forgive</u> / hit / please)

"Pardon" means nearly the same as "forgive", and so we have underlined "forgive" in the brackets.

Now do the questions below in the same way. Underline in the brackets the word which means most nearly the SAME as the word in capital letters.

1. The king GOVERNED his people justly.

(taught / judged / obeyed / released / ruled / encouraged)

2. Alice heard MOCKING laughter.

(hearty / childish / silent / muffled / hysterical / jeering)

3. His speech CONCLUDED the conference.

(began / ended / amused / upset / astonished / horrified)

Correct your answers. You should have underlined the words: (1) ruled, (2) jeering, and (3) ended.

The test proper contained 80 items.

8. Word Formation Test.

In this test you have to write in the blank space the correct word formed from the word in capital letters.

Here are some examples:

EMPLOY He went everywhere looking for employment.

FEED He was very hungry, so they gave him food.

FULL This milk will fill the jug.

CHILD She behaved in a very childish manner.

Now do these. Write the word clearly and be sure to spell it correctly.

FLY The aeroplane made the ..... in record time.

ANGRY He left the room in great .....

ITALY They drank ..... wine at lunch.

LONG The ..... of the snake was three feet.

Correct your answers. They should be:- (1) Flight, (2) Anger, (3) Italian, and (4) length.

The test proper contained 80 items.

9. Verbal Analogies Test.

Look at this example:-

Apple is to Fruit as (cabbage / robin / sheep) is to (fish / vegetable / insect).

"Cabbage" is underlined in one set of brackets and "vegetable" in the other set, because just as an apple is a fruit so a cabbage is a vegetable.

Here is another example:-

Kitten is to Cat as (calf / puppy / lamb) is to (horse / lion / dog)

"Puppy" and "dog" are underlined because just as a kitten is a young cat so a puppy is a young dog.

Now do these. In each question underline TWO words, one in each set of brackets.

(1) Chalk is to Blackboard as (draw / duster / pencil) is to (rubber / paper / clean)

(2) July is to Summer as (December / month / warm) is to (Christmas,/ cold / winter)

(3) Hand is to Glove as (arm / foot / head) is to (boot / body / toe)

Correct your answers. You should have underlined the words:- (1) pencil, paper (2) December, winter (3) foot, boot.

The test proper contained 80 items.

10. Number and Letter Series Test.

The alphabet is printed here to help you with the questions below.

A B C D E F G H I J K L M N O P Q R S T U V W X Y Z

Look at these letters:-

..... D F H J .....

F is the second letter in the alphabet after D, H is the second letter after F, and J is the second letter after H. In the blank space at the beginning, therefore, we must write B, and in the blank space at the end we must write L. Thus:-

....B.... D F H J ....L....

Now look at these numbers:-

..... 5, 8, 11, 14 .....

Each number is three more than the number before it. In the blank space at the beginning, therefore, we write 2, so that 5 is 3 more than 2; and in the blank space at the end we write 17, which is 3 more than 14. Thus:-

....2.... 5, 8, 11, 14 ...17....

In the same way, in each of the questions below there is a rule which tells us how one letter, or number, is found from those coming before or after it. You have to find out what the rule is, and then write in each of the two blank spaces what should go there.

See if you can write the correct letter, or number, in each of the blank spaces below:-

(1) ..... B X C X D X .....

(2) ..... 4, 6, 8, 10 .....

Correct your answers. In the first question, you should have written X at the beginning and E at the end. In the second question, you should have written 2 at the beginning and 12 at the end.

Letter and Number Series were arranged alternately, there being 44 series in all. One mark was given for each correct entry and so in effect the test contained 88 items.

11. Word Series Test.

In this test you have to think what the best order of the things mentioned would be, and then underline the FIRST and LAST of the new order.

Example 1. Shilling / penny / pound / half a crown / sixpence.

Putting these in order of value we have: "penny, sixpence, shilling, half a crown, pound." The first and last words in our new order are "penny" and "pound," so we have underlined them above.

Example 2. Brown / yellow / white / cream

We have underlined "Brown" and "white" because brown is the darkest colour and white is the lightest.

Now do these. Underline the FIRST and the LAST of the new order, that is, TWO things in each question.

1. C / E / D / B / A

2. County / village / city / town

Correct your answers. You should have underlined "A" and "E" in the first questions; "County" and "village" in the second.

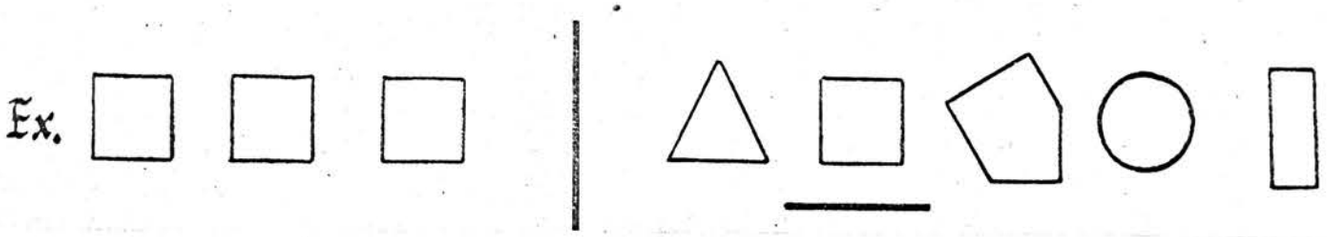
The test contained 80 items.

12. Jenkins' "Scale of Non-Verbal Mental Ability".

This test is in five sections each separately timed. An example of each section is given below.

(1) Spatial Classification - Similarity.

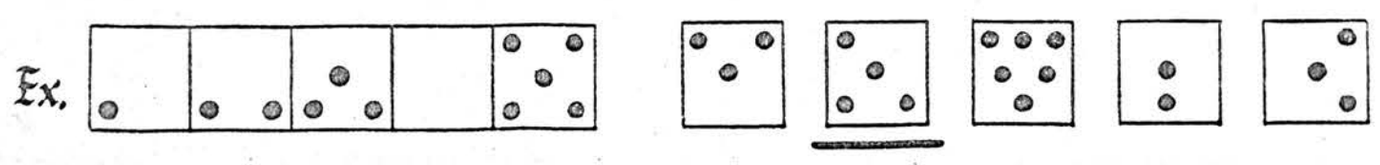
On the left of each of the rows below there are three figures which are alike. On the right there are five more figures. Find which ONE of these is most like the three figures on the left and draw a line under it. (The first one has been done for you.)



This sub-test contained 16 items for which the time allowance was 5 minutes.

(2) Spatial Series Completion

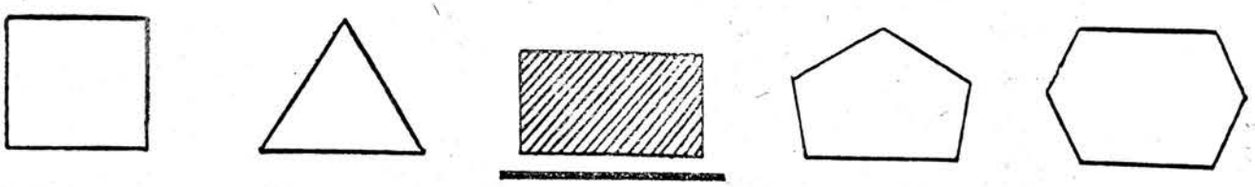
To the left in each of the lines below there are five squares arranged in order. ONE of these squares has been left empty. Find which one of the five squares on the right should take the place of the empty square and draw a line under it. (The first one has been done for you.)



This sub-test contained 18 items for which the time allowance was 5 minutes.

(3) Spatial Classification - Dissimilarity.

In each of the rows below there are five figures. Find ONE figure in each row which is most unlike the other four and draw a line under it. (The first one has been done for you.)

Ex. 

This sub-test contained 16 items for which the time allowance was 5 minutes.

(4) Spatial Series.

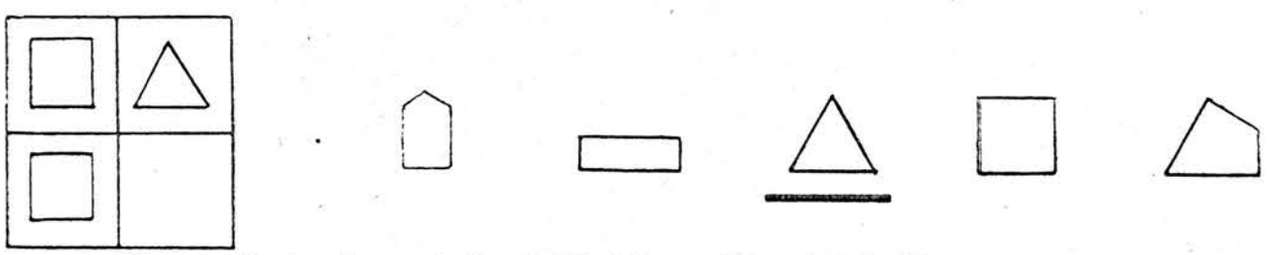
Each of the sets of figures below can be arranged in order. Think of each set arranged in order and draw a line under the ONE which comes in the middle. (The first one has been done for you.)

Ex. 

This sub-test contained 16 items for which the time allowance was 5 minutes.

(5) Matrices.

In the big square on the left of each line below, one of the four small squares has been left empty. ONE of the five figures to the right should fill the empty square. Find this figure and draw a line under it. (The first one has been done for you.)

Ex. 

This sub-test contained 19 items for which the time allowance was 10 minutes.

13. Mechanical Arithmetic Test.

Here are some examples of the sums you have to do in this test. Look at the top of each sum, see whether it says add, subtract, multiply, or divide, and then find the answer.

1. ADD	2. SUBTRACT	3. MULTIPLY	4. DIVIDE
32 15 47	786 263	538 4	963 by 3

Correct your answers. You should have:- (1) 94.
(2) 523. (3) 2152. (4) 321.

14. Problem Arithmetic Test.

Here are some examples of the sums you have to do in this test. See if you can do them.

You may work the sums in your head: or you may do your working on the page if you wish.

1. How many inches are there in 3 yds.? _____ inches

2. What fraction of a stone is 7 lbs? Give your answer in its lowest terms. _____

3. How many seconds are there in $3\frac{1}{2}$ minutes? _____ seconds

4. How many pieces of wood each 3 in. long can be got out of a plank 7 ft. 9 in. long? _____ pieces

Correct your answers. You should have:- (1) 108, (2) $\frac{1}{2}$, (3) 210, and (4) 31.

The test contained 74 items.

CHAPTER V.

THE EXPERIMENTAL DATA

(1) The Test Scores.

The scores of 206 boys and 229 girls in 14 tests provide the numerical data on which our investigation is based. As the first step in analysing these data, frequency distributions of raw scores were compiled for each of the fourteen tests - boys and girls separately. These are presented, in histogram form, in Figures 3 to 16.

Apart from two tests, Space Test 4/R which proved rather difficult especially for girls, and the Mechanical Arithmetic test which was too easy, the tests were of the right order of difficulty and gave good discrimination. The difficult nature of Space Test 4/R can be explained by the fact that this test was designed to cover a rather wide age range, in order that it could be used in an experiment[44] with 12 - 13 year old boys.

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44. R. Robertson, The Space Factor at Seven Plus and Twelve Plus. Unpublished B.Ed. Thesis, Edinburgh University, 1949.

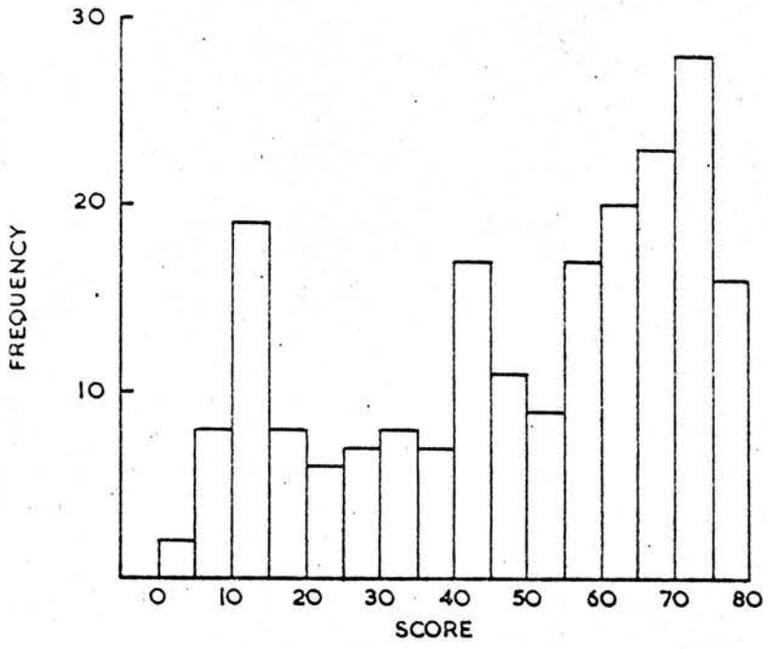

Fig. 3 a HISTOGRAM SHOWING DISTRIBUTION OF RAW SCORES FOR SPACE TEST I/R — BOYS

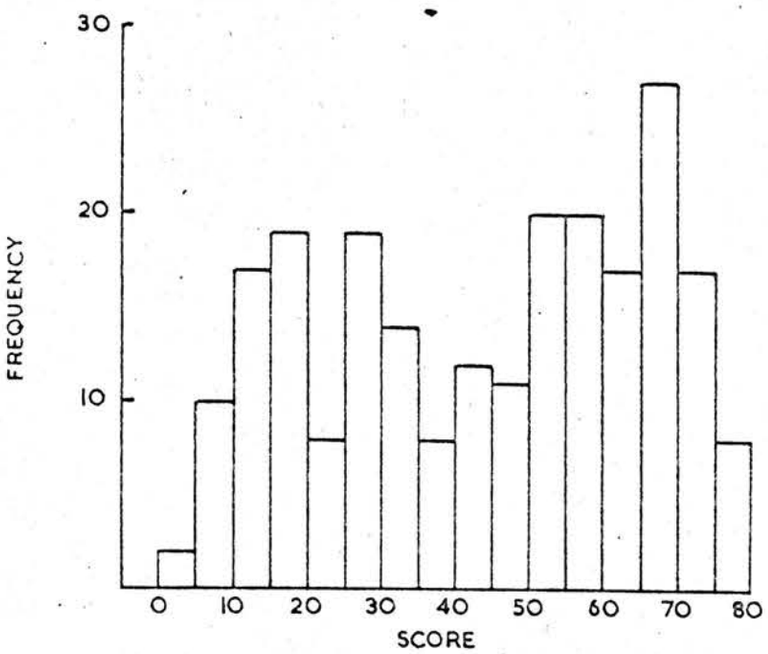

Fig. 3 b HISTOGRAM SHOWING DISTRIBUTION OF RAW SCORES FOR SPACE TEST I/R — GIRLS

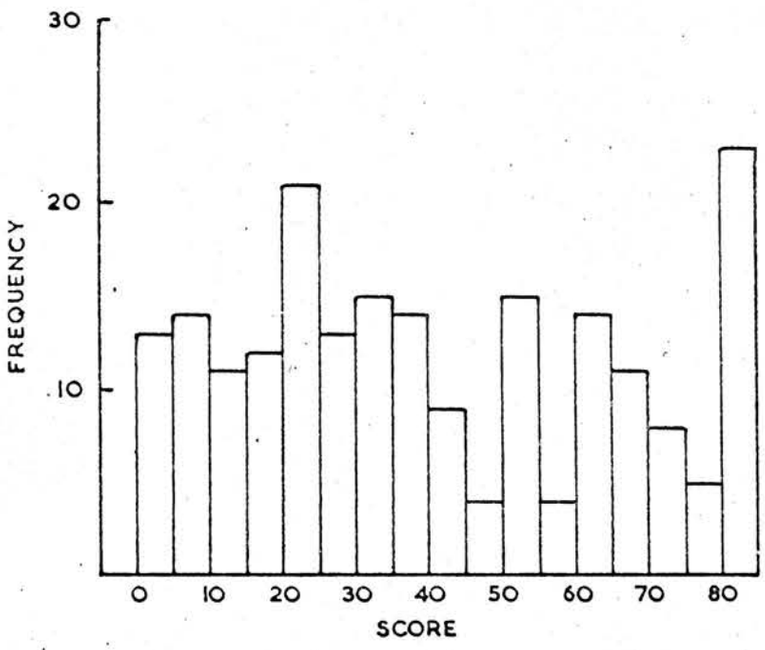

Fig. 4a HISTOGRAM SHOWING DISTRIBUTION OF RAW SCORES FOR SPACE TEST 2/R —BOYS

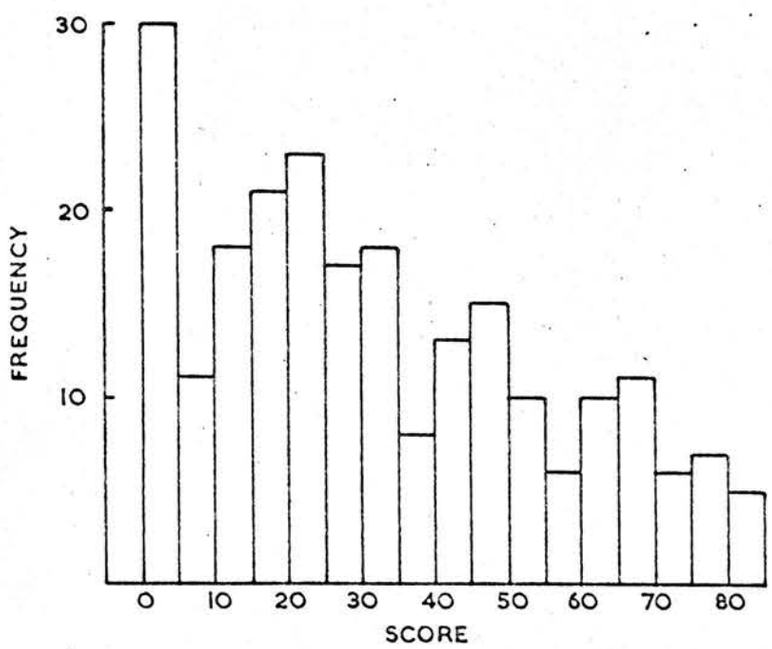

Fig. 4b HISTOGRAM SHOWING DISTRIBUTION OF RAW SCORES FOR SPACE TEST 2/R —GIRLS

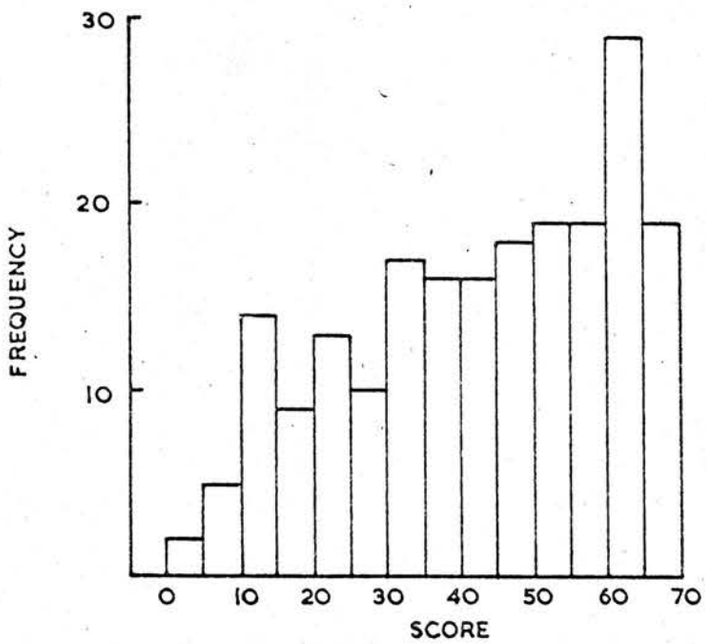

Fig. 5a HISTOGRAM SHOWING DISTRIBUTION OF RAW SCORES FOR SPACE TEST 3/R — BOYS

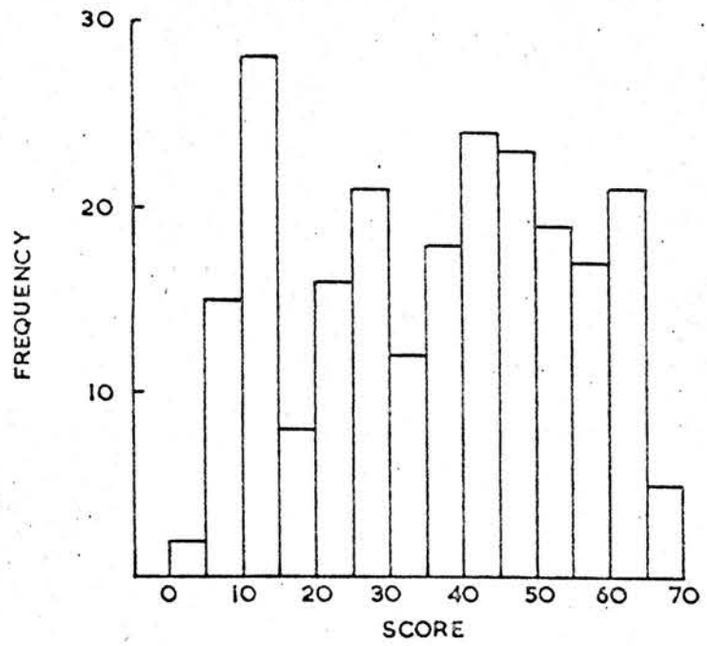

Fig. 5b HISTOGRAM SHOWING DISTRIBUTION OF RAW SCORES FOR SPACE TEST 3/R — GIRLS

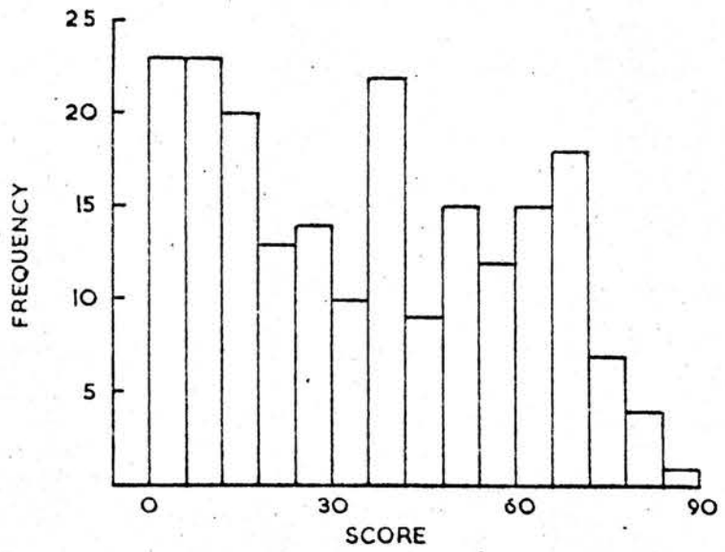

Fig. 6a HISTOGRAM SHOWING DISTRIBUTION OF RAW SCORES FOR SPACE TEST 4/R — BOYS

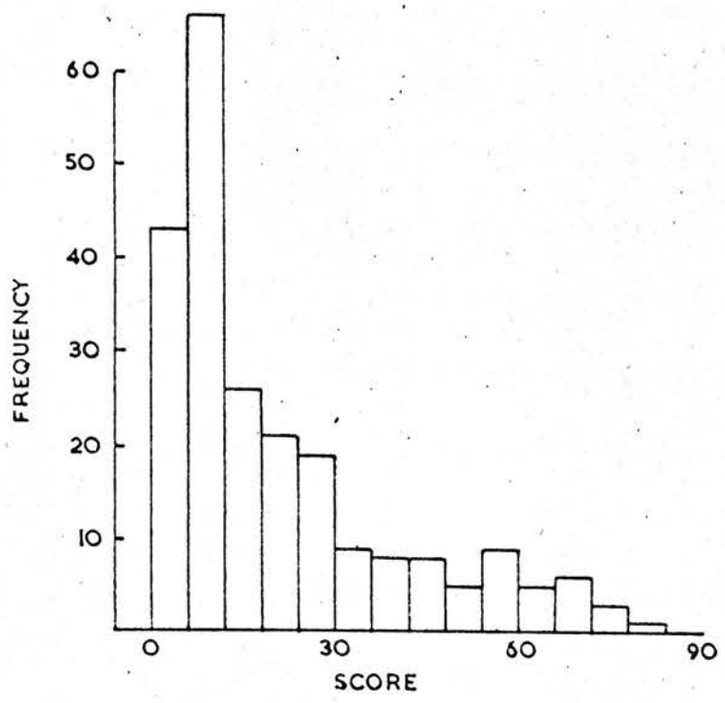

Fig. 6b HISTOGRAM SHOWING DISTRIBUTION OF RAW SCORES FOR SPACE TEST 4/R — GIRLS

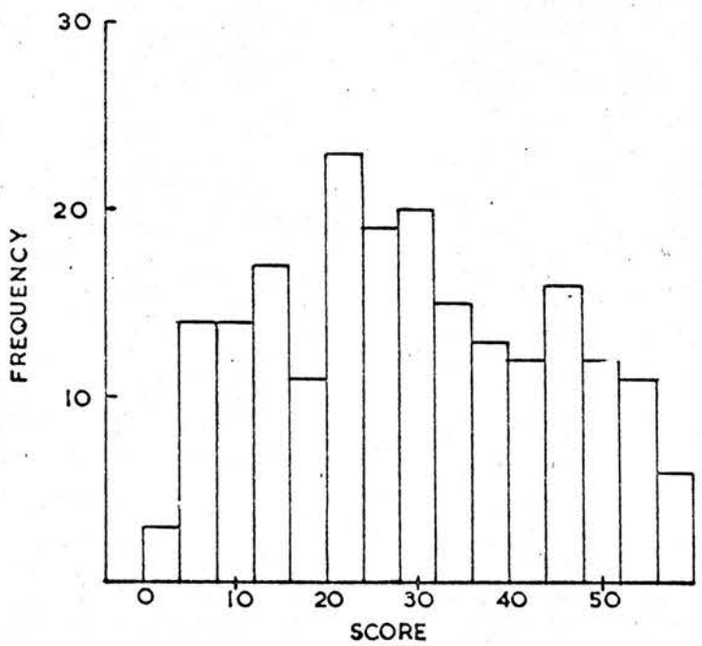

Fig. 7a HISTOGRAM SHOWING DISTRIBUTION OF RAW SCORES FOR SPACE TEST 5/R — BOYS

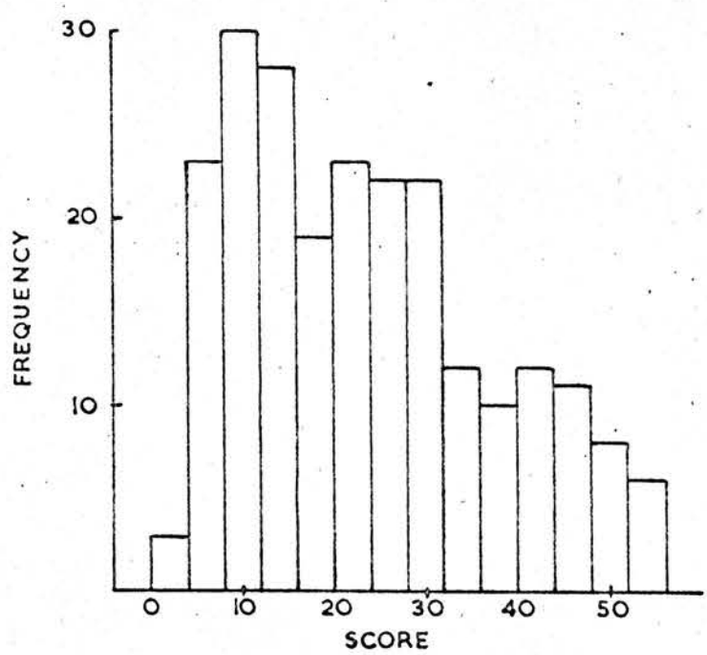

Fig. 7b HISTOGRAM SHOWING DISTRIBUTION OF RAW SCORES FOR SPACE TEST 5/R — GIRLS

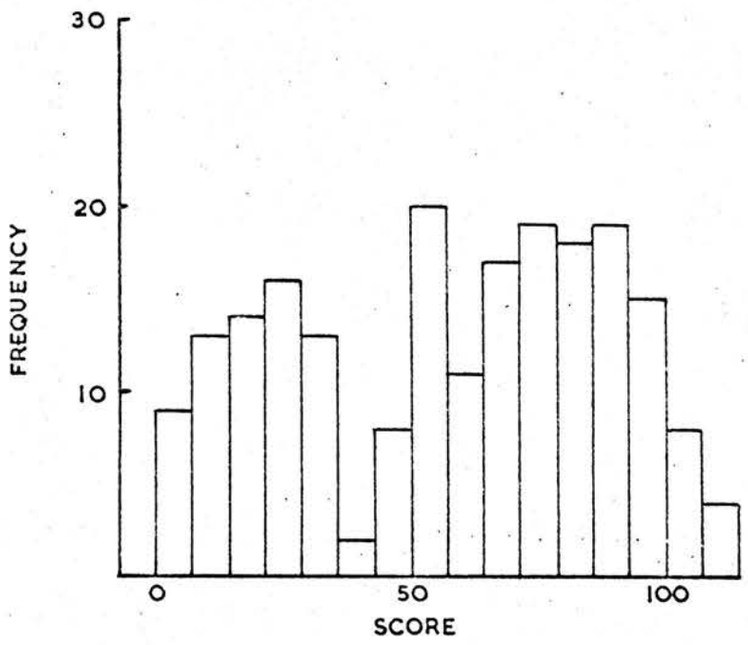

Fig. 8a HISTOGRAM SHOWING DISTRIBUTION OF RAW SCORES FOR SPACE TEST 6/R — BOYS

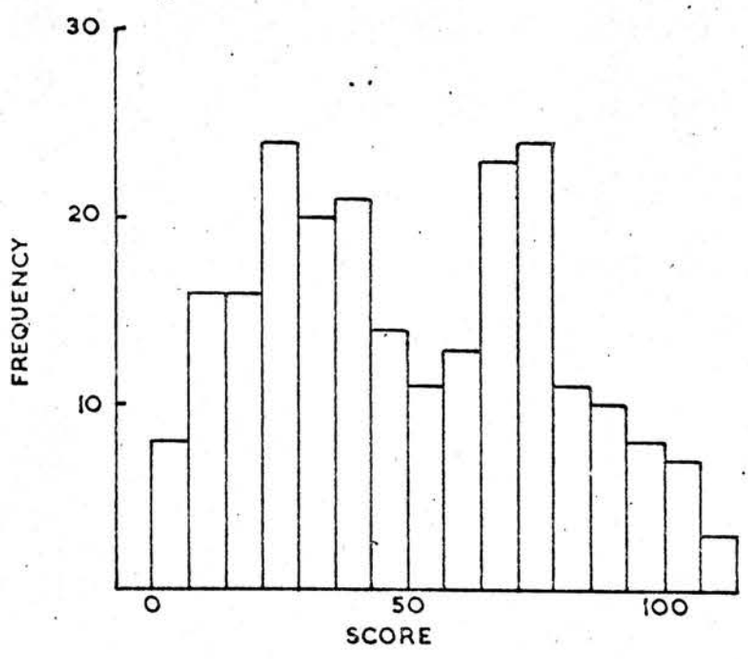

Fig. 8b HISTOGRAM SHOWING DISTRIBUTION OF RAW SCORES FOR SPACE TEST 6/R — GIRLS

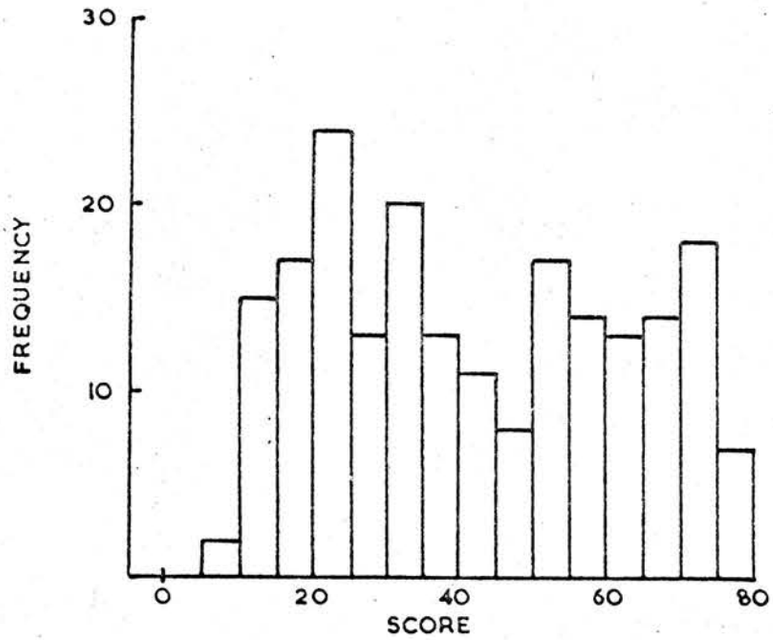

Fig. 9 a. HISTOGRAM SHOWING DISTRIBUTION OF RAW SCORES FOR SYNONYMS TEST —BOYS

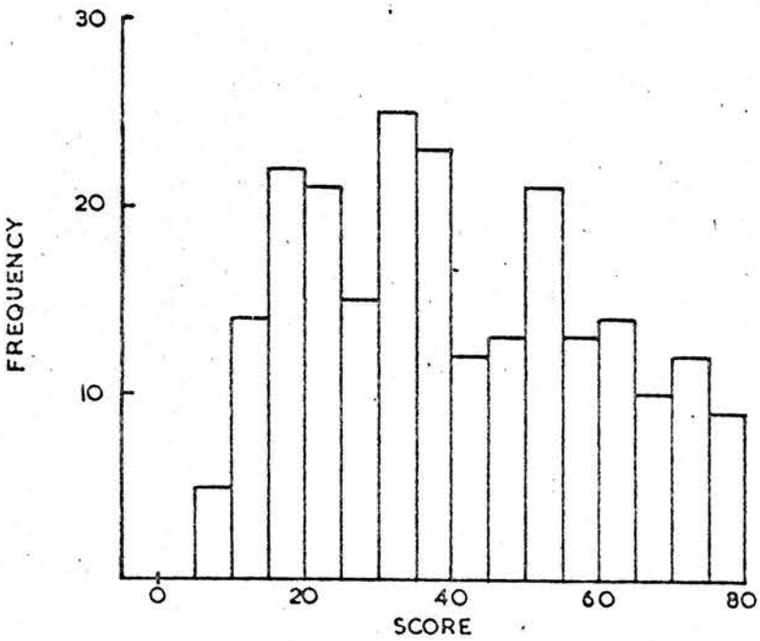

Fig. 9b. HISTOGRAM SHOWING DISTRIBUTION OF RAW SCORES FOR SYNONYMS TEST — GIRLS

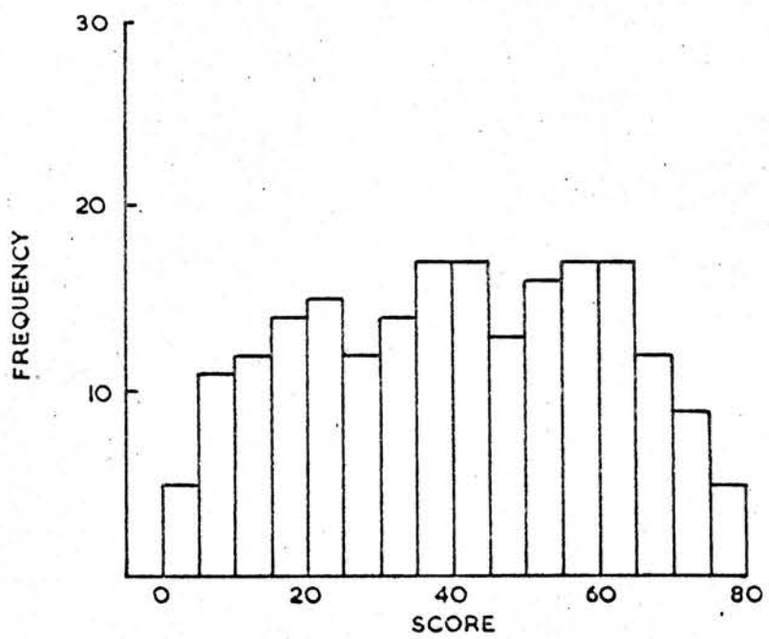

Fig. 10a. HISTOGRAM SHOWING DISTRIBUTION OF RAW SCORES FOR WORD FORMATION TEST — BOYS

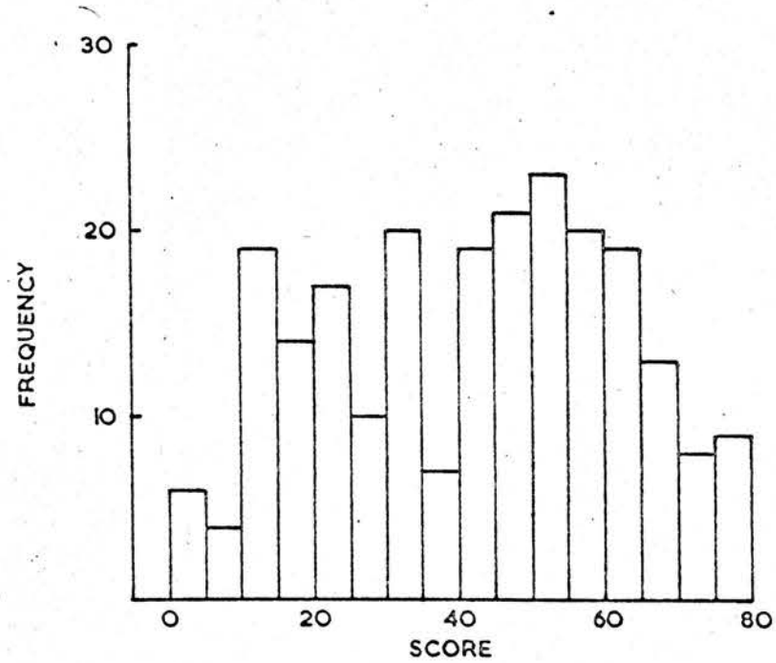

Fig. 10b. HISTOGRAM SHOWING DISTRIBUTION OF RAW SCORES FOR WORD FORMATION TEST — GIRLS

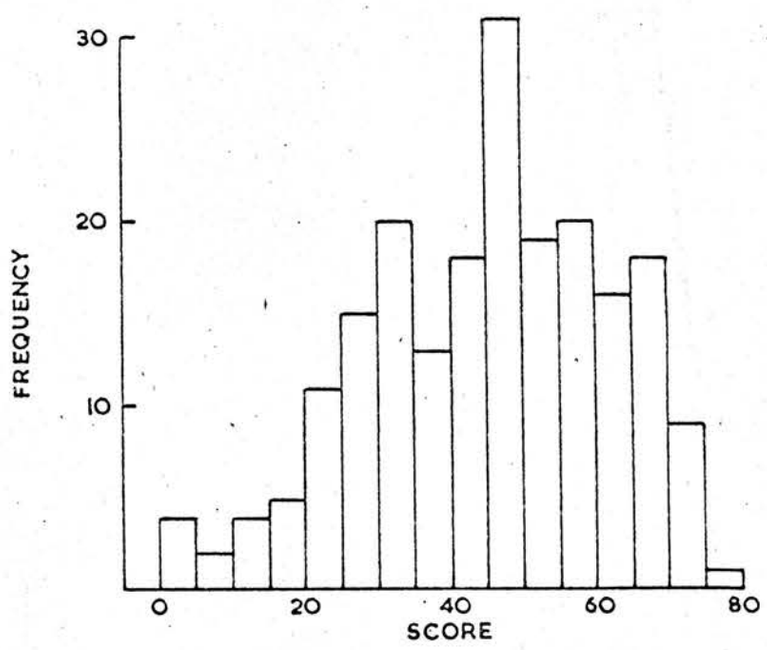

Fig. 11a. HISTOGRAM SHOWING DISTRIBUTION OF RAW SCORES FOR VERBAL ANALOGIES TEST —— BOYS

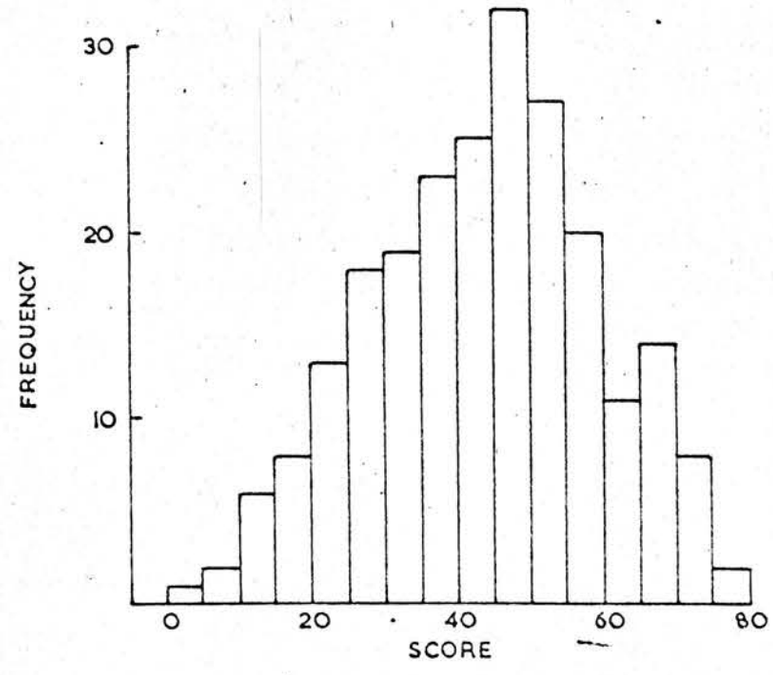

Fig. 11 b. HISTOGRAM SHOWING DISTRIBUTION OF RAW SCORES FOR VERBAL ANALOGIES TEST —GIRLS

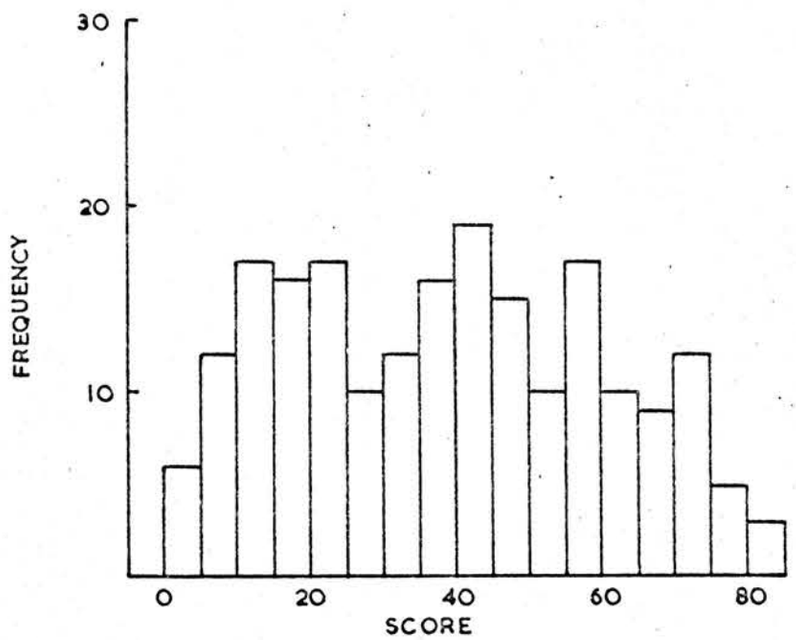

Fig. 12 a. HISTOGRAM SHOWING DISTRIBUTION OF RAW SCORES FOR NO. LETTER SERIES TEST — BOYS

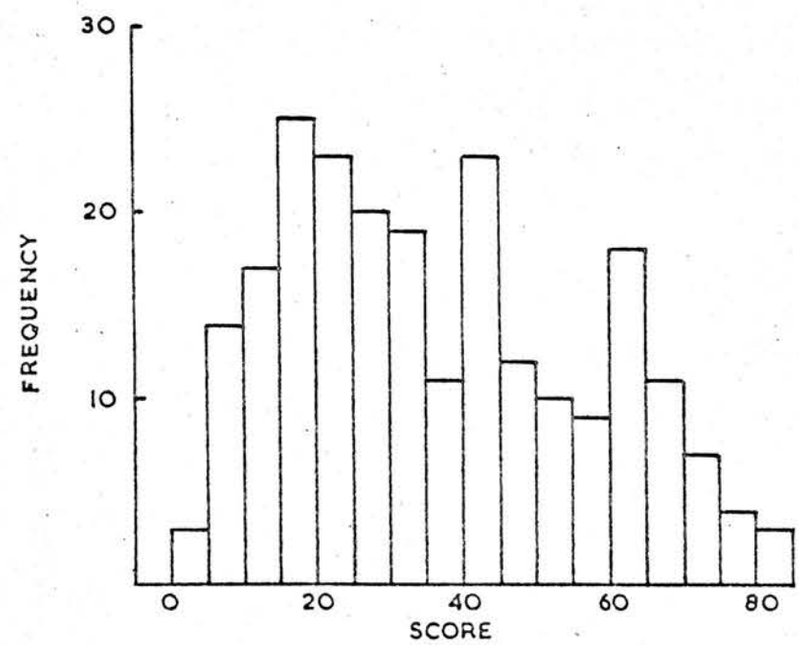

Fig. 12b. HISTOGRAM SHOWING DISTRIBUTION OF RAW SCORES FOR NO. LETTER SERIES TEST — GIRLS

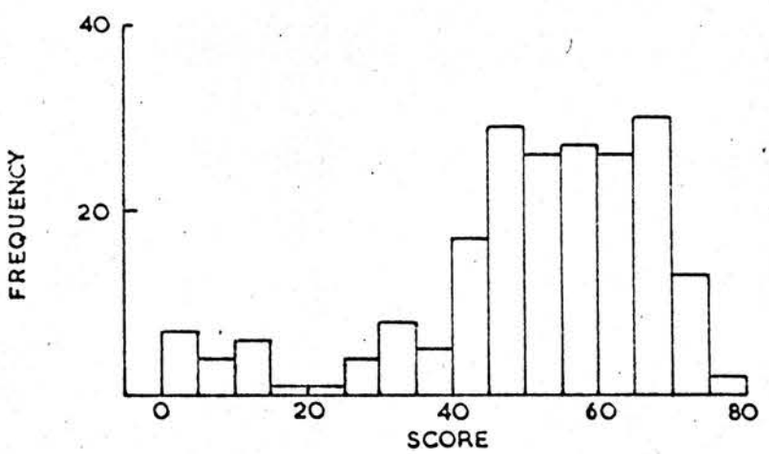

Fig. 13a. HISTOGRAM SHOWING DISTRIBUTION OF RAW SCORES FOR WORD SERIES TEST —— BOYS

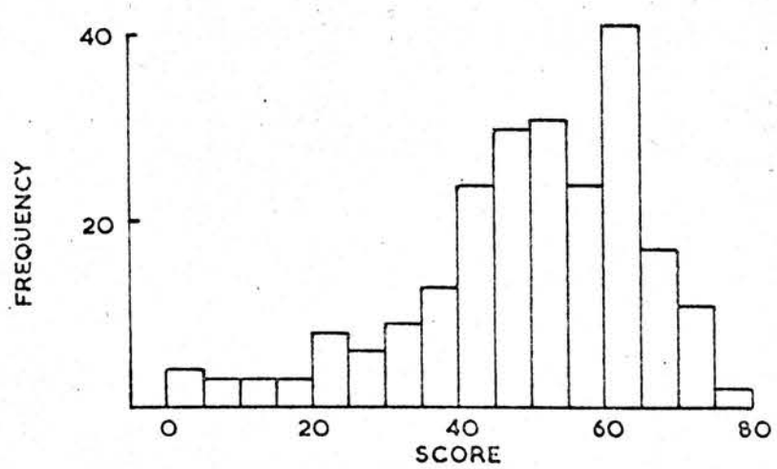

Fig. 13b. HISTOGRAM SHOWING DISTRIBUTION OF RAW SCORES FOR WORD SERIES TEST —— GIRLS

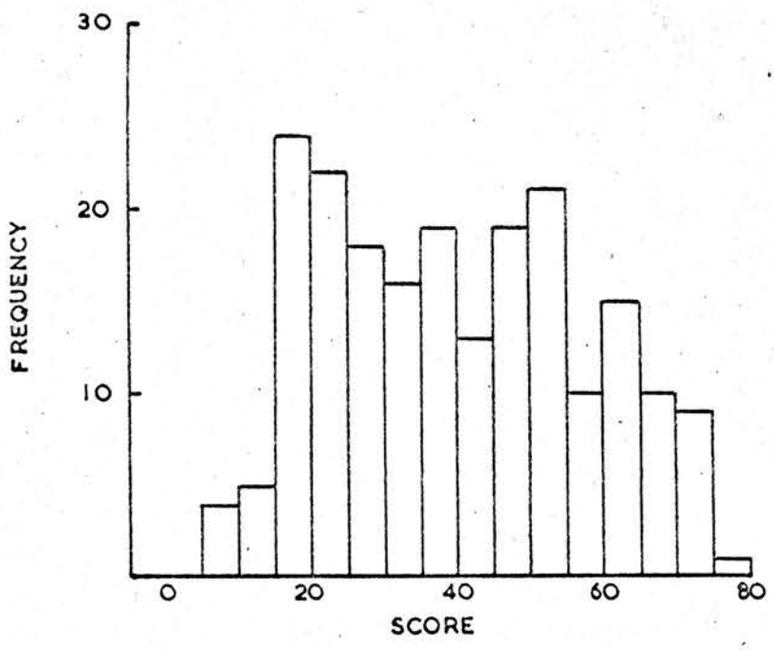

Fig.14 a. HISTOGRAM SHOWING DISTRIBUTION OF RAW SCORES FOR JENKINS' TEST — BOYS

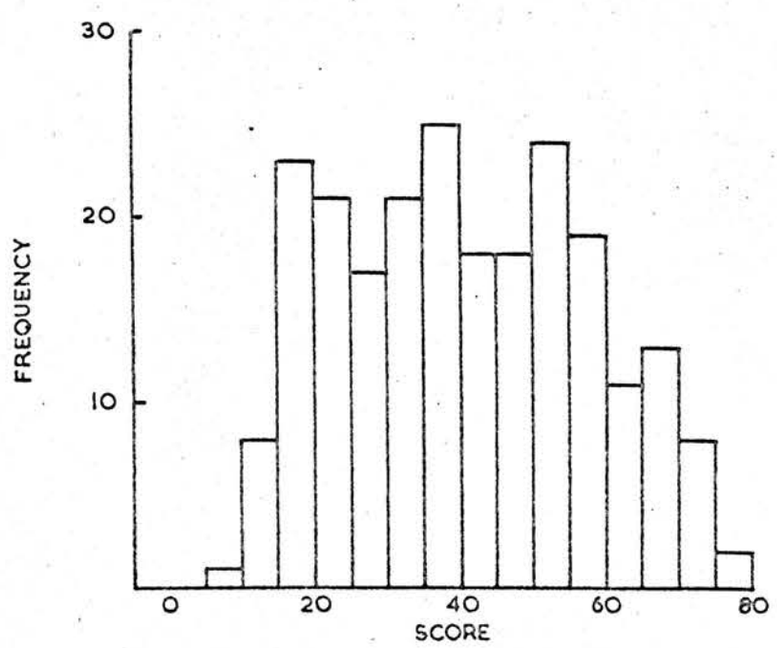

Fig. 14b. HISTOGRAM SHOWING DISTRIBUTION OF RAW SCORES FOR JENKINS' TEST — GIRLS

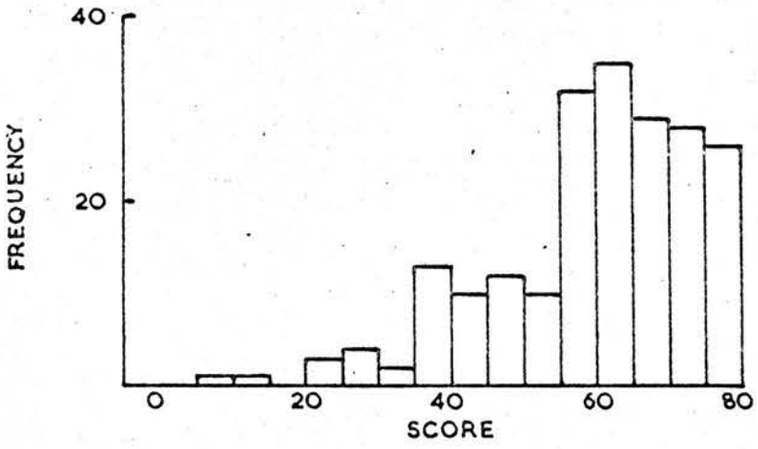

Fig. 15a. HISTOGRAM SHOWING DISTRIBUTION OF RAW SCORES FOR MECHANICAL ARITHMETIC TEST — BOYS

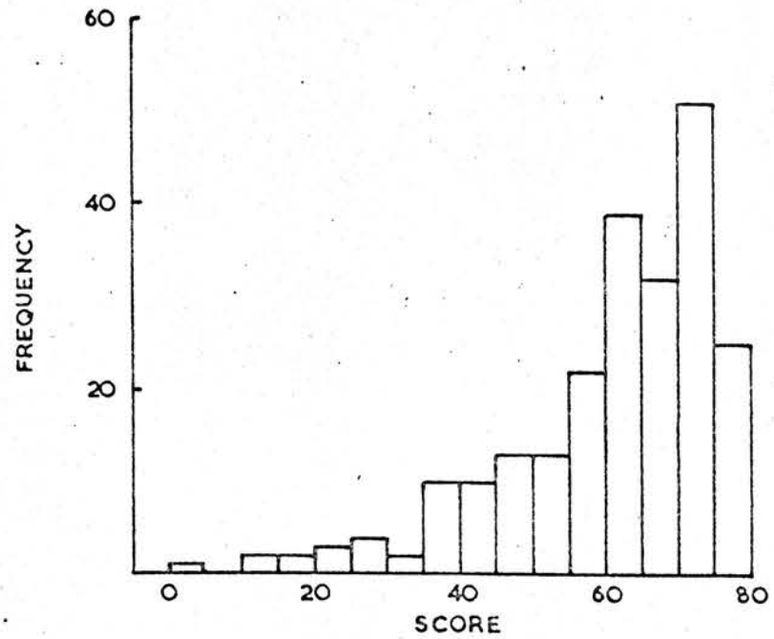

Fig. 15 b. HISTOGRAM SHOWING DISTRIBUTION OF RAW SCORES FOR MECHANICAL ARITHMETIC TEST — GIRLS

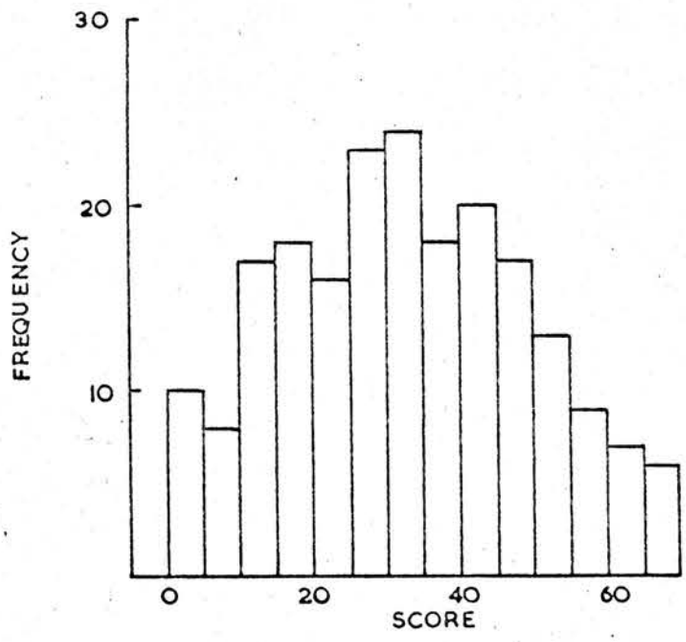

Fig. 16a. HISTOGRAM SHOWING DISTRIBUTION OF RAW SCORES FOR PROBLEM ARITHMETIC TEST —— BOYS

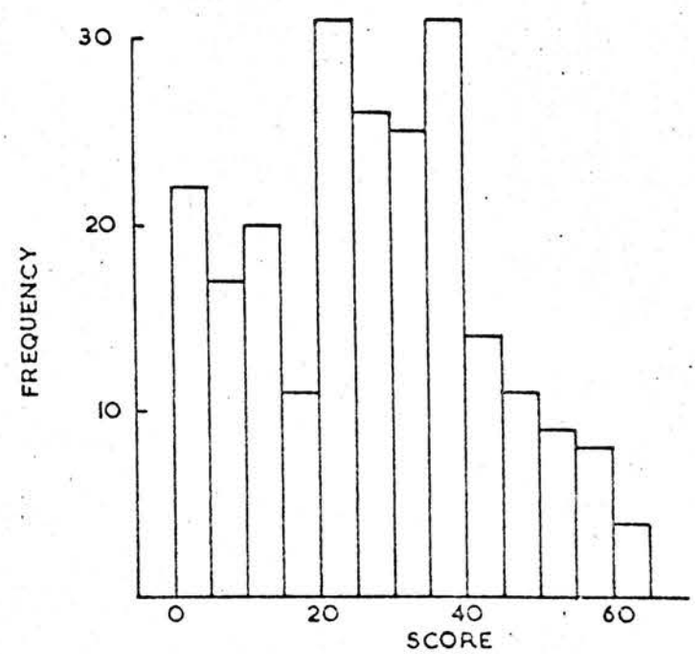

Fig. 16b. HISTOGRAM SHOWING DISTRIBUTION OF RAW SCORES FOR PROBLEM ARITHMETIC TEST — GIRLS

Mean test scores and standard deviations were next calculated. On account of the fact that the tests contain different numbers of items, these means and standard deviations are not directly comparable. Consequently, the mean scores were changed to percentages and the standard deviations altered on the basis of direct proportionality to the values they would possess in a one-hundred item test. The results of these calculations are given in Table IV for the boys, and in Table V for the girls. The mean scores quoted are the true means obtained by summing the test scores and dividing by the number of scores, while the standard deviations quoted are those obtained from the data, grouped so as to give approximately sixteen intervals. It will be seen that the standard deviations are all very high and therefore satisfactory.

TABLE IV MEANS AND STANDARD DEVIATIONS OF RAW SCORES - BOYS.
N = 206

Test	No. of Items	Mean.	Mean as Percentage	Standard Deviation	S.D. 100 item Equivalent.
1. Space 1/R	80	49.30	61.62	22.52	28.15
2. Space 2/R	86	41.02	47.70	25.47	29.62
3. Space 3/R	70	43.43	62.04	18.10	25.86
4. Space 4/R	100	35.55	35.55	23.81	23.81
5. Space 5/R	60	28.91	48.18	15.04	25.07
6. Space 6/R	113	57.05	50.49	30.05	26.59
7. Synonyms	80	41.95	52.44	20.38	25.48
8. Word Formation	80	39.85	49.82	20.35	25.44
9. Verbal Analogies	80	44.65	55.81	16.88	21.10
10. No. Letter Series	88	38.28	43.50	21.42	24.34
11. Word Series	80	50.35	62.93	17.46	21.83
12. Non-verb. Intell., Jenkins	85	39.33	46.27	17.71	20.83
13. Mechanical Arithmetic	80	59.15	73.93	14.21	17.77
14. Problem Arithmetic	74	32.19	43.50	16.79	22.63

TABLE V MEANS AND STANDARD DEVIATIONS OF RAW SCORES - GIRLS.
N = 229

Test	No. of Items	Mean.	Mean as Percentage	Standard Deviation	S.D. 100 items Equivalent
1. Space 1/R	80	44.31	55.39	21.64	27.05
2. Space 2/R	86	33.00	38.38	22.93	26.66
3. Space 3/R	70	37.00	52.85	18.02	25.74
4. Space 4/R	100	20.54	20.54	19.27	19.27
5. Space 5/R	60	23.22	38.70	13.64	22.73
6. Space 6/R	113	49.99	44.24	27.65	24.47
7. Synonyms	80	39.79	49.74	19.35	24.18
8. Word Formation	80	41.46	51.83	20.17	25.22
9. Verbal Analogies	80	43.18	53.97	15.76	19.70
10. No. Letter Series	88	36.08	41.00	20.33	23.10
11. Word Series	80	49.14	61.42	15.87	19.84
12. Non-verb. Intell., Jenkins	85	40.43	47.56	17.06	20.08
13. Mechanical Arithmetic	80	60.20	75.25	14.80	18.51
14. Problem Arithmetic	74	27.13	36.66	15.66	21.16

(2) Sex Differences in Test Peformance.

A comparison of the test results of the group of boys with those of the girls is our next concern. The two groups being roughly parallel with respect to age and both educational and social background, significant differences will be of particular interest.

By comparing corresponding entries in Tables IV and V we see that, except in Test 13, boys' standard deviations are all higher than girls'. There are, also, marked differences in the mean scores for certain of the tests. In order to examine the significance of these differences, Fisher's "t" test was used. The standard error of the difference between means was calculated using the following formula, which is applicable to large samples:

$$\text{Standard error} = \sqrt{\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}}$$

where s_1^2 and s_2^2 represent the variances of the score distributions for boys and girls respectively

and n_1 and n_2 represent the numbers of boys and girls respectively.

"t" was then calculated by dividing the difference in means by this standard error.

The results of the comparison are shown in Table VI.

TABLE VI SEX DIFFERENCES IN TEST PERFORMANCE.

Test	Mean as Percentage		Diff. (B - G) %	't'- value	Whether Significant
	Boys	Girls			
1. Space 1/R	61.62	55.39	6.23	2.93	S.(P<.01)
2. Space 2/R	47.70	38.38	9.32	3.99	S.(P<.001)
3. Space 3/R	62.04	52.85	9.19	5.30	S.(P<.001)
4. Space 4/R	35.55	20.54	15.01	7.17	S.(P<.001)
5. Space 5/R	48.18	38.70	9.48	6.86	S.(P<.001)
6. Space 6/R	50.49	44.24	6.25	2.25	S.(P<.05)
7. Synonyms	52.44	49.74	2.70	1.41	N.S.
8. Word Formation	49.82	51.83	-2.01	1.03	N.S.
9. Verbal Analogies	55.81	53.97	1.84	<1.00	N.S.
10. No. Letter Series	43.50	41.00	2.50	1.25	N.S.
11. Word Series	62.93	61.42	1.51	<1.00	N.S.
12. Non-verb. Intell., Jenkins	46.27	47.56	-1.29	<1.00	N.S.
13. Mechanical Arithmetic	73.93	75.25	-1.32	<1.00	N.S.
14. Problem Arithmetic	43.50	36.66	6.84	4.38	S.(P<.001)

It will be seen that the boys are, on the average, significantly superior to the girls in all the space tests. For four of these tests the differences are significant to a very high degree, since the "t" values exceed 3.291, which is the .1% level of significance. In other words, this means that the probability of obtaining such a great difference by chance is less than 1 in 1000.

In addition, we see that the boys are very highly superior to girls in the problem arithmetic test, while the remaining differences are not significant.

Mean "Intelligence Quotient" of the Groups.

We have seen that, according to the Jenkins' "Scale of Non-Verbal Ability", there is no significant difference between the mean levels of intelligence of the two groups. Converting raw scores to "Intelligence Quotients", we find that the mean I.Q. of the girls is 104 and that of the boys 103. This is of particular interest in view of the marked superiority of boys over girls in all space tests and also in the problem arithmetic test. Practice effect probably accounts for the fact that both means are somewhat greater than 100, since the Jenkins' test was administered at the end of the experiment.

(3) Reliability of the Tests.

The extent to which the test results are vitiated by chance errors can be assessed if we know the reliability of each test. Now a test is reliable when it gives consistent results. Consequently, in order to measure the reliability of a test, we should administer it twice to the same group and observe the extent of agreement between the two testings. In our experiment, since it was clearly not possible to administer the tests twice, it became necessary to use estimates of reliability based on a single testing. The procedure adopted was to correlate the scores of odd and even numbered items for each test. Strictly speaking, in this way we measure the internal consistency of the test; but this is a legitimate estimate of reliability, for we expect a test which is consistent within itself, to give consistent results when administered on different occasions. Nevertheless, we must bear in mind that it is an over-estimate of reliability, on account of the fact that errors in the odd and even halves of the test are correlated.

In making the calculations, a random sample of 100 boys' scripts was selected for each test and the product-moment correlation between odd and even item scores determined. The Spearman-Brown formula was then used to obtain the reliability of the test as a whole (r_{11}), from the correlation between the test halves ($r_{\frac{1}{2}\frac{1}{2}}$). The results are recorded in Table VII.

TABLE VII.

THE RELIABILITY COEFFICIENTS OF THE TESTS N = 100.

Test	Reliability Coefficients	
	$(r_{\frac{11}{22}})$	(r_{11})
1. Space 1/R	.934	.966
2. Space 2/R	.968	.984
3. Space 3/R	.932	.965
4. Space 4/R	.976	.988
5. Space 5/R	.938	.968
6. Space 6/R	.986	.993
7. Synonyms	.948	.974
8. Word Formation	.939	.968
9. Verbal Analogies	.926	.960
10. No.-Letter Series	.902	.949
11. Word Series	.971	.986
12. Non-verb. Intell., Jenkins	.913	.954
13. Mechanical Arithmetic	.949	.975
14. Problem Arithmetic	.932	.965

CHAPTER VI.

THE FACTORIAL ANALYSIS.

(1) The Intercorrelations.

Our first task is to calculate the intercorrelations which express the relationships between the various tests in the experimental battery. Now the theory of correlation is based on the assumption that the variables correlated are normally distributed. We have seen, however, that our own raw score distributions were not normal; they were, in fact, purposely rendered almost rectangular by our attempt to obtain good discrimination. The question arises, therefore, as to whether we should normalize the test score distributions before calculating the correlations. An answer to this question appears to have been given by Thurstone and his collaborators[45] who have found that while it is desirable to normalize the raw score distributions, failure to do so does not seriously affect the results of the subsequent analysis. In the light of these findings it was decided to correlate raw scores directly.

Including age, which is to be partialled out, we have fifteen variables, and since boys' and girls' results are to be analysed separately, there will be two matrices, each containing 105 correlation

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45. L.L. Thurstone, Multiple-Factor Analysis, p.369 University of Chicago Press, 1947.

coefficients. Product-moment correlations were calculated by the formula:-

$$r = \frac{\sigma_1^2 + \sigma_2^2 - \sigma_d^2}{2\,\sigma_1\,\sigma_2}$$

where σ_1^2 and σ_2^2 are the variances of the two test variables we wish to correlate, and σ_d^2 is the variance of their differences.

Having already calculated the variances of all the tests, we require only σ_d^2 for each possible pair of tests. Considerable assistance was obtained from students in making these calculations, which were all carefully checked. Table VIII gives the matrix of intercorrelations for boys and Table IX the corresponding matrix for girls.

TABLE VIII CORRELATION MATRIX - BOYS (N = 206).

Variable		0.	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.
Age	0.		-.0663	-.2330	-.2145	-.0462	-.1767	-.1809	-.3266	-.3924	-.3482	-.1782	-.3368	-.2677	-.4385	-.4033
Space Test 1/R	1.			..2918	.6879	.3709	.5446	.3588	.3016	.3124	.3748	.3835	.3115	.4639	.1791	.2983
Space Test 2/R.	2.				.5930	.3409	.5158	.3967	.4337	.4470	.4092	.4472	.3569	.4908	.3153	.4359
Space Test 3/R	3.					.4345	.6299	.4516	.4705	.4407	.4875	.5042	.5000	.5685	.3194	.4434
Space Test 4/R	4.						.4982	.4944	.2680	.2464	.3355	.4171	.3397	.4159	.1399	.2722
Space Test 5/R	5.							.4593	.4522	.4166	.5057	.5655	.4916	.6266	.3251	.4502
Space Test 6/R	6.								.4306	.3387	.5293	.6047	.4970	.5809	.3321	.4327
Synonyms Test	7.									.8299	.7108	.5196	.6694	.6091	.5219	.7030
Word Formation Test	8.										.6216	.4488	.6282	.5253	.6298	.7644
Verbal Analogies Test	9.											.6666	.6872	.7118	.5048	.6576
No. & Letter Test	10.												.5907	.7321	.4100	.5730
Word Series Test	11.													.5726	.5147	.6663
Non-verb.Intell.Test,Jenkins	12.														.3945	.5836
Mechanical Arithmetic	13.															.7634
Problem Arithmetic	14.															

TABLE IX. CORRELATION MATRIX - GIRLS (N = 229).

Variable		0.	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.
Age	0.		-.1880	-.1949	-.2450	-.1027	-.1378	-.2125	-.1912	-.3207	-.2185	-.1523	-.1164	-.2592	-.3069	-.2830
Space Test 1/R	1.			.4655	.7113	.4543	.5372	.4790	.2777	.3526	.4204	.4918	.4315	.4946	.3456	.4148
Space Test 2/R	2.				.7261	.5080	.6073	.5228	.3891	.4323	.5062	.5322	.5500	.5558	.3964	.5549
Space Test 3/R	3.					.5137	.6636	.5675	.4593	.4813	.5380	.5756	.5590	.6328	.4250	.5526
Space Test 4/R	4.						.5830	.4697	.2126	.2154	.3446	.4579	.3686	.4132	.1922	.3409
Space Test 5/R	5.							.5894	.4007	.4186	.5068	.6643	.5590	.6178	.4109	.5706
Space Test 6/R	6.								.3680	.3768	.5366	.6264	.5183	.6018	.3286	.4775
Synonyms Test	7.									.8351	.7290	.5115	.6646	.6298	.5600	.7449
Word Formation Test	8.										.6840	.5405	.6709	.6155	.6476	.7645
Verbal Analogies Test	9.											.6913	.7692	.7444	.5777	.7295
No. & Letter Series Test	10.												.6696	.7154	.4781	.6724
Word Series Test	11.													.7186	.6105	.7445
Non-verb.Intell.Test,Jenkins	12.														.4942	.6805
Mechanical Arithmetic	13.															.7236
Problem Arithmetic	14.															

Correlations greater in absolute value than .136 for boys and .130 for girls are significant at the 5% level. The relatively high negative correlations with age, particularly for the boys in arithmetic, are caused by the presence in the experimental group of an appreciable number of both advanced and retarded children. Owing to the fact that the majority of the age correlations are significant, our decision to partial out age can be justified.

(2) Partialling Out Age from the Intercorrelations.

The formula for the correlation of a pair of variables from which a third variable has been partialled out is:-

$$r_{12.3} = \frac{r_{12} - r_{13}\, r_{23}}{\sqrt{(1 - r_{13}^2)(1 - r_{23}^2)}}$$

where r_{12} , r_{13} and r_{23} are the correlations between variables 1 and 2, 1 and 3 and 2 and 3 respectively.

The calculations were made using an adaptation of Aitken's method of pivotal condensation[46]. This method is most convenient for partialling out one or more variables from a large correlational matrix as it provides a progressive and independent check on the calculations. Table X gives the matrix of correlations for boys, age having been partialled out, and Table XI gives the corresponding girls' matrix.

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46. Room 70 Laboratory Notes, Moray House, Edinburgh University.

TABLE X. BOYS' CORRELATION MATRIX - AGE PARTIALLED OUT.

Test		1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.
Space Test 1/R	1.		.2848	.6912	.3690	.5426	.3534	.2986	.3121	.3760	.3786	.3078	.4641	.1673	.2978
Space Test 2/R	2.			.5716	.3399	.4958	.3707	.3890	.3975	.3599	.4240	.3041	.4572	.2438	.3839
Space Test 3/R	3.				.4352	.6158	.4297	.4337	.3968	.4508	.4849	.4651	.5431	.2566	.3991
Space Test 4/R	4.					.4983	.4947	.2679	.2485	.3411	.4161	.3446	.4193	.1332	.2778
Space Test 5/R	5.						.4415	.4241	.3836	.4814	.5514	.4662	.6109	.2799	.4208
Space Test 6/R	6.							.3996	.2959	.5058	.5916	.4709	.5619	.2860	.3997
Synonyms Test	7.								.8071	.6738	.4961	.6286	.5729	.4576	.6602
Word Formation Test	8.									.5624	.4187	.5727	.4742	.5537	.7196
Verbal Analogies Test	9.										.6555	.6456	.6848	.4179	.6023
No. & Letter Series Test	10.											.5728	.7219	.3753	.5569
Word Series Test	11.												.5317	.4337	.6152
Non-verb. Intell. Test, Jenkins	12.													.3200	.5393
Mechanical Arithmetic	13.														.7124
Problem Arithmetic	14.														

Mean correlation = .470

TABLE XI. GIRLS' CORRELATION MATRIX - AGE PARTIALLED OUT.

Test		1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.
Space Test 1/R	1.		.4452	.6985	.4452	.5255	.4575	.2508	.3142	.3957	.4772	.4199	.4701	.3080	.3838
Space Test 2/R	2.			.7133	.5002	.5975	.5024	.3654	.3981	.4844	.5184	.5413	.5335	.3606	.5312
Space Test 3/R	3.				.5065	.6558	.5441	.4335	.4384	.5121	.6518	.5509	.6080	.3790	.5197
Space Test 4/R	4.					.5773	.4608	.1976	.1937	.3320	.4499	.3609	.4024	.1697	.3268
Space Test 5/R	5.						.5787	.3851	.3991	.4932	.6571	.5519	.6085	.3910	.5595
Space Test 6/R	6.							.3414	.3335	.5141	.6151	.5086	.5793	.2833	.4454
Synonyms Test	7.								.8322	.7174	.4973	.6589	.6120	.5366	.7337
Word Formation Test	8.									.6641	.5252	.6734	.5819	.6091	.7415
Verbal Analogies Test	9.										.6822	.7674	.7297	.5498	.7133
No. & Letter Series Test	10.											.6641	.7081	.4586	.6638
Word Series Test	11.												.7176	.6080	.7469
Non-verb. Intell. Test, Jenkins	12.													.4511	.6554
Mechanical Arithmetic	13.														.6975
Problem Arithmetic	14.														

Mean correlation = .537

It is found that all correlations in both tables are significantly greater than zero. Also, with few exceptions, each correlation in the girls' matrix is higher than the corresponding correlation in the boys' matrix. The mean correlation given below each table was calculated by Fisher's "z" technique[47], and this technique was again used to test the significance of the difference between the mean correlations. Since there are 91 entries in each matrix and the correlations are based on the scores of 206 boys and 229 girls, the mean correlation for boys is treated as though it were calculated from $\left[91\ (206 - 3) + 3\right]$ pairs of observations and that for girls as though it were calculated from $\left[91\ (229 - 3) + 3\right]$ pairs of observations. The standard error of the difference between the two "Z" values is therefore $\sqrt{\frac{1}{91}\left(\frac{1}{203} + \frac{1}{226}\right)}$ and this is approximately .01. We find that the difference between the two "Z" values is .09 and as this is nine times its standard error it follows that the difference between the mean correlations is very highly significant. This result has an important bearing on later findings.

(3) Communalities.

Having obtained the correlation matrices, we must decide whether to place unity or communalities in the

47. R.A. Fisher, Statistical Methods for Research Workers, p. 204. Oliver and Boyd, Tenth Edition, 1946.

diagonal cells. This is a question of fundamental importance in factorial analysis, and one which must be decided with regard to the particular object in mind. If we insert unity in each diagonal, then theoretically we must be prepared to extract as many factors as there are tests. In practice however, several of these may be inappreciable, so enabling us to ignore them. On the other hand, if we insert communalities in the diagonal cells, we are able generally to reproduce the intercorrelations with a few common factors, but at the same time we introduce a specific factor into every test, the contribution of which to the total test variance is frequently quite considerable. Attention has been drawn to the advantages and disadvantages of using communalities by Sir Godfrey H. Thomson[48], and it is in the light of these criticisms that our decision to use communalities must be judged.

It is only with large correlation matrices that we can safely take the highest coefficient in each column as an estimate of the communality. If, therefore, we are to avoid the necessity of repeating the factorisation process, it is desirable to obtain the closest possible estimates of the communalities. Of the various alternative methods available, application of the "Centroid Number 1" formula is reported to give

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48. G.H. Thomson, The Factorial Analysis of Human Ability, pp. 334 - 37. University of London Press, Third Edition, 1948.

the most consistent results[49]. To check this formula, a preliminary investigation was carried out with a small matrix of nine variables, which had previously been factorised and for which one iteration had been completed[50]. The extent of agreement between the estimated and iterated communalities can be judged from the following table:-

Test	Communalities			
	Guessed	Obtained	Iterated	Formula
1.	.794	.851	.858	.782
2.	.794	.777	.760	.764
3.	.759	.753	.782	.729
4.	.763	.810	.791	.749
5.	.731	.671	.692	.693
6.	.630	.523	.495	.586
7.	.731	.743	.737	.712
8.	.668	.754	.812	.693
9.	.621	.514	.462	.467

By guessed communality is meant the highest ceofficient in each column. On the whole, the formula gives fairly close approximations to the iterated communalities (in the cases of tests 2, 5 and 9 the values are almost identical) and for this reason it was decided to use it here.

49. Francis F. Medland, "An Empirical Comparison of Methods of Communality Estimation", Psychometrika, Vol. XXII, No. 2, June, 1947.
50. L.F. Mills, The Properties of a Space Test, p. 31. Unpublished B.Ed. Thesis, Edinburgh University, 1947.

It may be asked: How is the accuracy of our factor loadings influenced by errors in communality estimation? An attempt will be made to answer this question.

In order to calculate factor loadings, we divide each column total by the square root of T, the sum of the entries in the matrix. The error in a factor loading will therefore be $\frac{1}{\sqrt{T}}$ times the error in communality estimation. T itself, however, will be subject to error, but if, as is probable, we under-estimate communalities by the formula as often and to the same extent as we over-estimate them, this error will be trivial.

For each of our particular matrices, $\sqrt{T}$ was approximately 10. It follows, therefore, that a large error in communality estimation such as .2, would produce an error of .02 in the corresponding first factor loading. The evidence is, that in general, communality estimates are not likely to be out by more than .1 and consequently first factor loadings by more than .01.

With the object of estimating the magnitude of error in the second and subsequent factor loadings and of checking the consistency of the centroid formula, it was decided to re-calculate the communalities for each residual matrix and compare them with the residual communalities. A summary of the results, to two significant figures, is given in Tables XII - XV.

TABLE XII.

DISCREPANCIES BETWEEN RE-ESTIMATED AND RESIDUAL COMMUNALITIES FOR THE FIRST FACTOR RESIDUALS.

Test	Boys			Girls		
	Estimated	Residual	Difference	Estimated	Residual	Difference
1	.27	.24	.03	.22	.17	.05
2	.15	.19	-.04	.16	.17	-.01
3	.30	.25	.05	.25	.17	.08
4	.19	.19	.00	.17	.20	-.03
5	.13	.12	.01	.13	.08	.05
6	.17	.11	.06	.11	.13	-.02
7	.25	.22	.03	.30	.29	.01
8	.28	.27	.01	.29	.22	.07
9	.09	.11	-.02	.12	.10	.02
10	.12	.11	.01	.06	.02	.04
11	.12	.12	.00	.06	.07	-.01
12	.10	.11	-.01	.07	.05	.02
13	.28	.26	.02	.17	.22	-.05
14	.28	.17	.11	.13	.05	.08
$\sqrt{T}$	4.0			4.1		

TABLE XIII.

DISCREPANCIES BETWEEN RE-ESTIMATED AND RESIDUAL COMMUNALITIES FOR THE SECOND FACTOR RESIDUALS.

Test	Boys			Girls		
	Estimated	Residual	Difference	Estimated	Residual	Difference
1	.16	.14	.02	.11	.08	.03
2	.10	.13	-.03	.06	.09	-.03
3	.16	.14	.02	.11	.08	.03
4	.07	.09	-.02	.06	.01	.05
5	.06	.03	.03	.04	.01	.03
6	.11	.10	.01	.08	.05	.03
7	.11	.09	.02	.10	.05	-.04
8	.10	.07	.03	.08	.05	.03
9	.07	.08	-.01	.05	.05	.00
10	.10	.11	-.01	.08	.04	.04
11	.06	.08	-.02	.04	.02	.02
12	.09	.08	.01	.08	.06	.02
13	.14	.10	.04	.11	.09	.02
14	.12	.06	.06	.06	.01	.05
$\sqrt{T}$	2.5			2.1		

TABLE XIV.

DISCREPANCIES BETWEEN RE-ESTIMATED AND RESIDUAL COMMUNALITIES FOR THE THIRD FACTOR RESIDUALS.

Test	Boys			Girls		
	Estimated	Residual	Difference	Estimated	Residual	Difference
1	.16	.10	.06	.09	.07	.02
2	.15	.08	.07	.08	.06	.02
3	.10	.04	.06	.07	.00	.07
4	.08	.07	.01	.05	.03	.02
5	.04	.04	.00	.06	.02	.04
6	.08	.01	.07	.02	.02	.00
7	.07	.07	.00	.10	.07	.03
8	.05	.01	.04	.04	.03	.01
9	.06	.05	.01	.03	.02	.01
10	.04	.00	.04	.04	-.01	.05
11	.07	.06	.01	.03	.02	.01
12	.07	.07	.00	.04	.03	.01
13	.13	.12	.01	.11	.07	.04
14	.10	.08	.02	.08	.03	.05
$\sqrt{T}$	2.0			1.7		

TABLE XV.

DISCREPANCIES BETWEEN RE-ESTIMATED AND RESIDUAL COMMUNALITIES FOR THE FOURTH FACTOR RESIDUALS.

Test	Boys			Girls		
	Estimated	Residual	Difference	Estimated	Residual	Difference
1	.16	.12	.04	.08	.06	.02
2	.13	.12	.01	.07	.06	.01
3	.09	.04	.05	.05	.01	.04
4	.08	.07	.01	.05	.03	.02
5	.04	.04	.00	.04	.02	.02
6	.07	.04	.03	.02	.01	.01
7	.03	.00	.03	.08	.04	.04
8	.04	.03	.01	.06	.03	.03
9	.05	.02	.03	.03	.02	.01
10	.05	.02	.03	.03	.02	.01
11	.08	.05	.03	.03	.02	.01
12	.08	.05	.03	.02	.02	.00
13	.05	.00	.05	.05	.03	.02
14	.03	.02	.01	.03	.01	.02
$\sqrt{T}$	1.8			1.4		

In most cases, the discrepancy between the re-estimated and residual communality is very small. It must be remarked, however, that our decision to insert mean values of residual and re-estimated communalities in the diagonals of each residual matrix has reduced the magnitude of the discrepancies for the second and subsequent factor residuals.

It is reasonable to suppose that the true communalities would give residuals somewhere between the pairs of values given in the above table, and since the mean of each pair was taken as an estimate of the true residual communality, it is probable that the error in each of the second and subsequent factor loadings will not exceed $\frac{1}{\sqrt{T}}$ times half the corresponding difference given in the table. Such errors are small enough to be ignored.

(4) The Centroid Matrices.

Thurstone's "centroid" method was used to factorise the correlation matrices. Sign-changing was effected in each residual matrix until all the column totals were positive or zero. This was done by reflecting one variable at a time as illustrated by Thurstone in "Multiple-Factor Analysis"[51]. For a small matrix of five variables, this method was found to give identical results with that in which the test with the largest number of negative coefficients is

51. Thurstone, Op. Cit., pp. 165-6.

reflected first and the process continued until each column has a majority of positive signs.

McNemar's[52] criterion was applied in order to decide how many factors should be extracted, since this is probably the most satisfactory test available. The procedure is to take out factors until σ_1 reaches or falls below $1/\sqrt{N}$

where $\sigma_1 = \frac{\sigma_s}{(1 - M_h^2)}$

σ_s = standard deviation of the residuals after s factors,

M_h^2 = mean communality for s factors,

and N = size of the sample.

For each matrix, five factors were found to be significant. Because of the importance of deciding how many factors to extract in a centroid analysis, and in view of the fundamental nature of this problem a review of the subject will follow in the next section.

As a result of the factorial analysis, we obtained the centroid matrices presented in Tables XVI and XVII.

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52. Q. McNemar, "On the Sampling Errors of Factor Loadings", Psychometrika, Vol. VI, 1942, pp. 141 - 52.

TABLE XVI. BOYS' MATRIX OF CENTROID LOADINGS - F.

Test	Factor Loadings					Communalities	
	I	II	III	IV	V	Obtained	Estimated
1. Space 1/R	.5627	.3354	-.2302	-.1048	.2475	.5544	.5600
2. Space 2/R	.5774	.1980	-.1780	-.0664	-.2155	.4551	.5200
3. Space 3/R	.7234	.3624	-.3401	-.1697	.1231	.8143	.7700
4. Space 4/R	.5267	.3271	.0761	.0686	-.1779	.4265	.4700
5. Space 5/R	.7128	.3065	-.0756	-.0588	.0283	.6120	.6300
6. Space 6/R	.6377	.1997	.3070	.1069	-.1542	.5760	.5200
7. Synonyms	.7613	-.3840	-.1688	.2701	-.0309	.8294	.8000
8. Word Formation	.7222	-.4554	-.2637	.0552	-.1486	.8236	.7900
9. Verbal Analogies	.7790	-.1352	.1575	.1734	.1683	.7083	.7200
10. No. Letter Series	.7651	.1077	.3098	.0456	.0843	.7021	.7000
11. Word Series	.7302	-.2059	.1126	.0877	.1269	.6121	.6500
12. Non-verb. Intell., Jenkins	.7961	.1490	.1314	.1312	.1140	.7035	.7400
13. Mechanical Arithmetic	.5404	-.4064	.0803	-.3509	-.1065	.5981	.5500
14. Problem Arithmetic	.7641	-.4048	.0915	-.2725	-.0935	.8391	.7500
Total	9.5991	-.0059	.0098	-.0845	-.0347	9.2545	9.1700
Sum of Squares of loadings	6.7017	1.3022	.5697	.3942	.2867	-	-
Percentage of total variance	47.869	9.301	4.069	2.816	2.048	66.103	-

TABLE XVII GIRLS' MATRIX OF CENTROID LOADINGS F.

Test	Factor Loadings					Communalities	
	I	II	III	IV	V	Obtained	Estimated
1. Space 1/R	.6007	.3453	-.1466	.1549	.0769	.5315	.5345
2. Space 2/R	.7020	.2754	-.1170	-.1074	-.2161	.6406	.6676
3. Space 3/R	.7736	.3653	-.3080	.1587	-.1114	.8644	.7694
4. Space 4/R	.5296	.4226	.0632	-.0855	.0784	.4765	.4784
5. Space 5/R	.7469	.3180	.0501	-.1477	.1422	.7035	.6375
6. Space 6/R	.6593	.2662	.2194	.0565	.0407	.5586	.5601
7. Synonyms	.7232	-.4933	-.0834	.2091	.0966	.8263	.8140
8. Word Formation	.7319	-.4570	-.1903	.0702	.1477	.8075	.7596
9. Verbal Analogies	.8158	-.2521	.1742	.0970	.0803	.7752	.7649
10. No. Letter Series	.7979	.0534	.2507	-.0117	.1034	.7132	.6588
11. Word Series	.8374	-.2095	.0952	-.0467	-.1164	.7699	.7706
12. Non-verb. Intell., Jenkins	.8217	-.0239	.1995	.1425	-.0580	.7393	.7231
13. Mechanical Arithmetic	.6293	-.3248	-.1626	-.2440	.0407	.5892	.6154
14. Problem Arithmetic	.8293	-.2830	-.0731	-.2088	.0904	.8250	.7388
Total	10.1986	0.0026	-.0287	.0371	.2349	9.8207	9.4927
Sum of Squares of loadings	7.5462	1.4277	0.4017	0.2768	.1681	-	-
Percentage of total variance	53.901	10.198	2.869	1.977	1.201	70.148	-

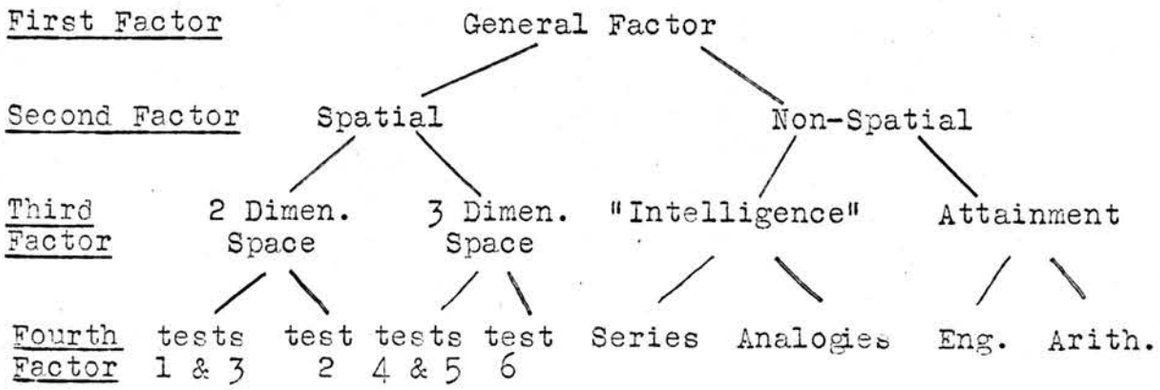
There is close agreement between estimated and obtained communalities, no discrepancy exceeding 0.1. On the average, a satisfactorily high percentage of the total test variance is accounted for by the five common factors. Nevertheless, for a few of the tests, particularly Space 4/R, a large proportion of the test variance must be attributed to specific factors. It is encouraging, however, to find at least one space test, namely 3/R, that is only slightly influenced by specific factors.

It appears that our sign-changing procedure has proved effective, the indication being, that we have extracted as much as possible of the total test variance with each successive factor. One point of interest is that for boys, the last three factors account for a relatively larger percentage of the common factor variance than for girls, the percentages being $\frac{8.933}{66.103}$ which is 13.51 as compared with $\frac{6.047}{70.148}$ which is 8.65. Unfortunately, there is no significance test for this difference which appears to be quite large.

Let us now consider the common factors themselves, for it will be remembered that some psychologists, in particular Sir Cyril Burt, often terminate the analysis at this stage. An illustration of Burt's method of interpreting the results will be given for the girls' matrix.

In the first place, we see that the first factor

loadings are all relatively high positive values, which reveals that the tests all cluster round the average or resultant vector which is interpreted as the general factor. The second factor is bipolar and has seven positive and seven negative loadings. Six of the positive loadings are associated with space tests and the seventh is almost zero. This factor therefore represents, according to Burt[53], a dichotomous classification of the tests into Spatial and Non-Spatial. The third factor is what Burt calls "doubly bipolar", indicating two distinct dichotomous sub-classifications - on the one hand, into two and three dimensional space tests and on the other into attainment and intelligence tests. If we proceed further, we find that the fourth factor separates the English tests from the Arithmetic. In fact, we might represent the classification diagrammatically as follows:-



53. C. Burt, The Factors of the Mind, pp. 311 - 14. University of London Press, 1940.

It must be emphasized, that while our results suggest a hierarchy such as the one drawn above, it is by no means as clearly defined as we have indicated. Indeed, it is doubtful whether all the sub-classifications below the second level of arborisation, possess real significance. In particular, the sub-division into two and three dimensional space tests is open to question, for apart from the slight differences between positive and negative loadings, there is an important reason against interpreting the latter group as being three dimensional. On a more careful scrutiny of the data, we find that Test 10, namely the Number-Letter Series Test, falls into this group and its loading is higher than any of the space tests. In fact, the resemblance in factorial composition of Tests 6 and 10, especially as far as the third factor is concerned, is a point which emerges more clearly in the rotation to simple structure.

Had we resolved to state our findings in accordance with the above procedure, we would not have begun with a centroid analysis. Rather we would have employed the principal axes solution which is free from the uncertainties involved in sign-changing, and for which more satisfactory significance tests of the factors extracted can be applied. Ideally, we might have used Lawley's "Method of Maximum Likelihood". As a consequence, no attempt will be made here to

infer the nature of the factors underlying the tests.

(5) The Number of Common Factors.

As already stated, a fundamental problem in the centroid method of analysis is to decide how many factors to extract from the correlation matrix. There appear to be two conflicting points of view regarding this matter. On the one hand, it has been suggested that it is better to under-factorize, so that error factors tempting psychological interpretation are not admitted, while on the other, that it is better to over-factorize on the grounds that the extra factors will not permit psychological interpretation and may therefore be ignored.

A cogent argument from the former stand-point relates to the fact, that on rotating the centroid axes, the later factors acquire variance from the earlier factors and thus may be mistakenly assumed to have an importance which probably is illusory. The case for the latter view-point is apparently based on an empirical study by Mosier[54], who found that he was better able to reproduce his original data by extracting and rotating too many, rather than too few, factors. Mosier's work, however, is open to the criticism made by Saunders[55], that he has assumed the errors in the correlation coefficients are merely random, which is

54. C.I. Mosier, "Influence of Chance Error on Simple Structure", Psychometrika, Vol. IV, pp.33-44, 1939.
55. D.R. Saunders, "Factor Analysis: Some Effects of Chance Error," Psychometrika, Vol. XIII, 4, pp. 251-7, 1948.

not so.

Thurstone too, holds the view that it is better to extract too many factors and allow the rotations to eliminate unnecessary factors as residuals which are not interpreted. He has, in fact, said:

"No matter what method of factoring is used, it is a safe rule to continue the factoring until one is sure that the factoring has gone far enough. Too many factors can do no harm, but too few factors are sure to cause trouble in identifying the structure. If too many factors are determined in the factor matrix before rotation of axes, then the residual factors appear in the rotation of axes, and they are left without interpretation".[56]

In support of this view is the fact that as one extracts more factors, the range separating the largest positive and largest negative loading for each successive factor progressively decreases. Now the rotated loadings for a factor do not exceed this range; in fact, they are usually somewhat smaller. To take a concrete example, let us consider our own factorial matrices. We see that the range between maximum positive and maximum negative loadings for the successive factors diminishes as follows:-

Factor	2	3	4	5
Boys	.82	.65	.62	.46
Girls	.92	.56	.45	.36

56. Multiple-Factor Analysis, p. 509.

We will not, therefore, expect to obtain fifth factor loadings in excess of .46 for boys and .36 for girls. Values for a sixth factor would have been appreciably smaller and hence of little significance. While applicable for orthogonal rotations, the above argument does not appear to hold when the factors are oblique, for we actually obtained a fifth factor loading of .545 for girls (Table XXII). The reason for this is that we have allowed our fifth reference axis to encroach too closely upon the second, the angle between them being 50°. As a consequence, our fifth factor merely reflects the second. We have, in fact, almost lost one of the common factor dimensions, as is clearly seen when one plots the configuration in relation to these two axes. The test points very nearly lie on a straight line. One may inquire: Why have we allowed the fifth factor to approach so near to the second? In reply, we may say that if we do not allow the fifth reference axis to depart considerably from orthogonality, then no appreciable loadings can be obtained for this factor. We appear, in this way, to have substantiated Thurstone's contention stated above. Also, in view of the fact that we are unable to interpret the fifth factors with any degree of confidence, it is apparent that we have taken out sufficient factors.

We will conclude the present chapter by drawing attention to the main disadvantage of the centroid

method, namely, that it does not enable the standard errors of the factor loadings to be computed. On the other hand, it does yield a reasonably close approximation to the statistically more satisfactory "principal component" solution, without excessive computational labour.

CHAPTER VII.

"SIMPLE STRUCTURE".

(1) Rotating the Centroid Axes.

Our object now is to rotate the centroid axes, so that each may be given the most plausible psychological interpretation. There being innumerable positions to which the axes can be rotated we require to place some restriction on the solution. In order to obtain what is perhaps the least subjective and in addition, the most invariant solution, we turn to the concept of "simple structure". This being our stated intention, we will indicate how the positions of the factorial axes were located, utilizing the method of extended vectors.

First of all, we will describe fully the rotations relating to the boys' data. The rotations for girls will then be given more briefly. For detailed instructions on each step in the computational procedure, the reader is referred to Thurstone's "Multiple-Factor Analysis"[57].

(a) Boys' Data.

The centroid factors of Table XVI are first extended. This is done by dividing each row by its first entry. In this way, we obtain the matrix E_o of Table XVIII, for which the first figure in each row is unity.

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57. pp. 230-58.

By plotting the four columns II_e, III_e, IV_e and V_e in pairs, we obtain six diagrams, which show two-dimensional sections of the hyper-plane at right angles to the first centroid axis. They are inspected for collinear points and five sets are chosen to determine the initial positions of the reference planes, and hence the reference axes, which are at right angles to them. We give the experimental diagrams in Figures 17 - 22 inclusive. The same scale has been used for each drawing, the squares being .25 by .25.

TABLE XVIII EXTENDED FACTORIAL MATRIX E_o - BOYS.

Test	I_e	II_e	III_e	IV_e	V_e
1. Space 1/R	1.0000	.5961	-.4091	-.1862	.4398
2. Space 2/R	1.0000	.3429	-.3083	-.1150	-.3732
3. Space 3/R	1.0000	.5010	-.4701	-.2346	.1702
4. Space 4/R	1.0000	.6210	.1445	.1302	-.3378
5. Space 5/R	1.0000	.4300	-.1061	-.0825	.0397
6. Space 6/R	1.0000	.3132	.4814	.1676	-.2418
7. Synonyms	1.0000	-.5044	-.2217	.3548	-.0406
8. Word Formation	1.0000	-.6306	-.3651	.0764	-.2058
9. Verbal Analogies	1.0000	-.1736	.2022	.2226	.2160
10. No. Letter Series	1.0000	.1408	.4049	.0596	.1102
11. Word Series	1.0000	-.2820	.1542	.1201	.1738
12. Non-verb. Intell., Jenkins	1.0000	.1872	.1651	.1648	.1432
13. Mechanical Arithmetic	1.0000	-.7520	.1486	-.6493	-.1971
14. Problem Arithmetic	1.0000	-.5298	.1197	-.3566	-.1224

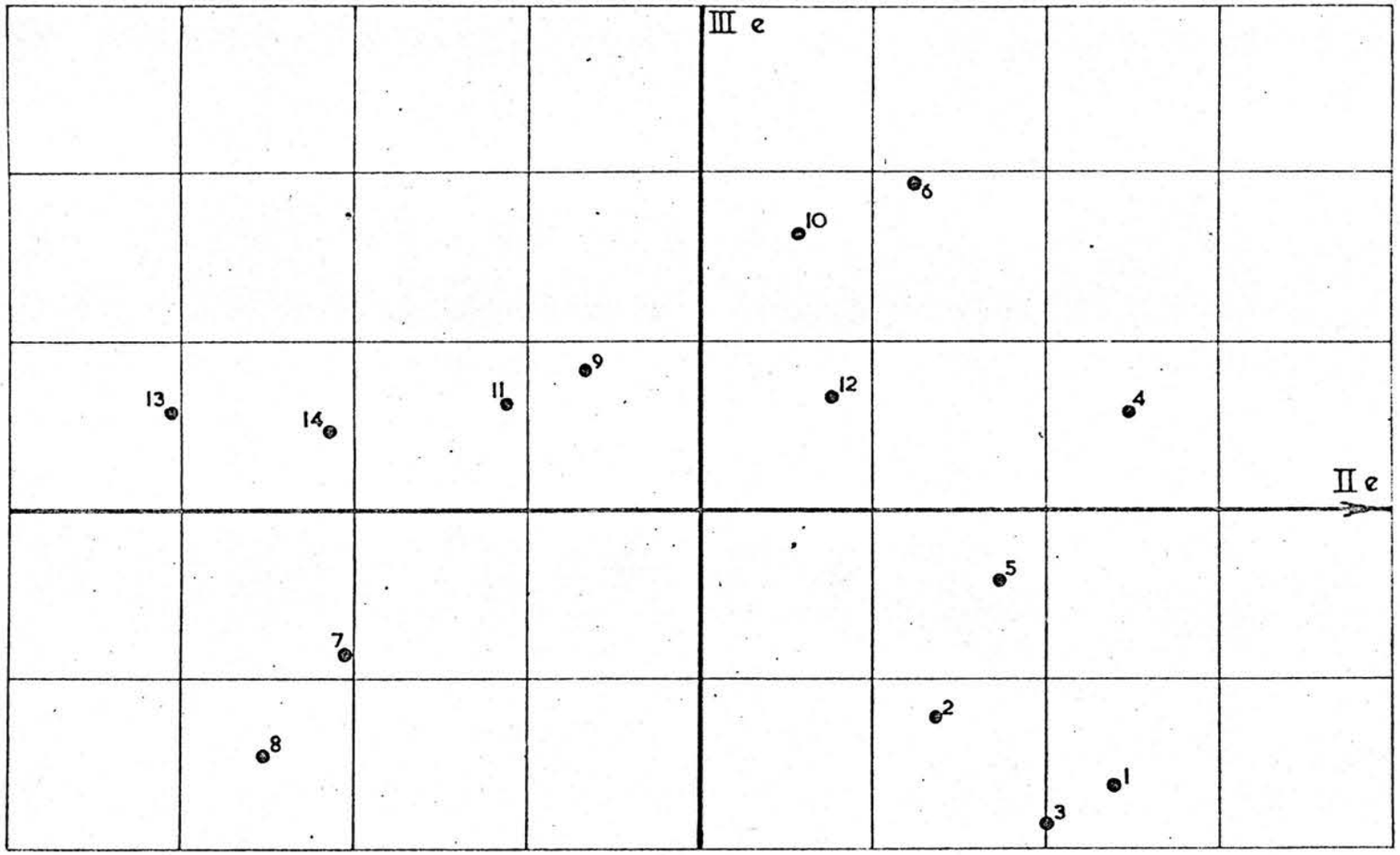

Fig. 17 FACTORS IIe & IIIe — BOYS

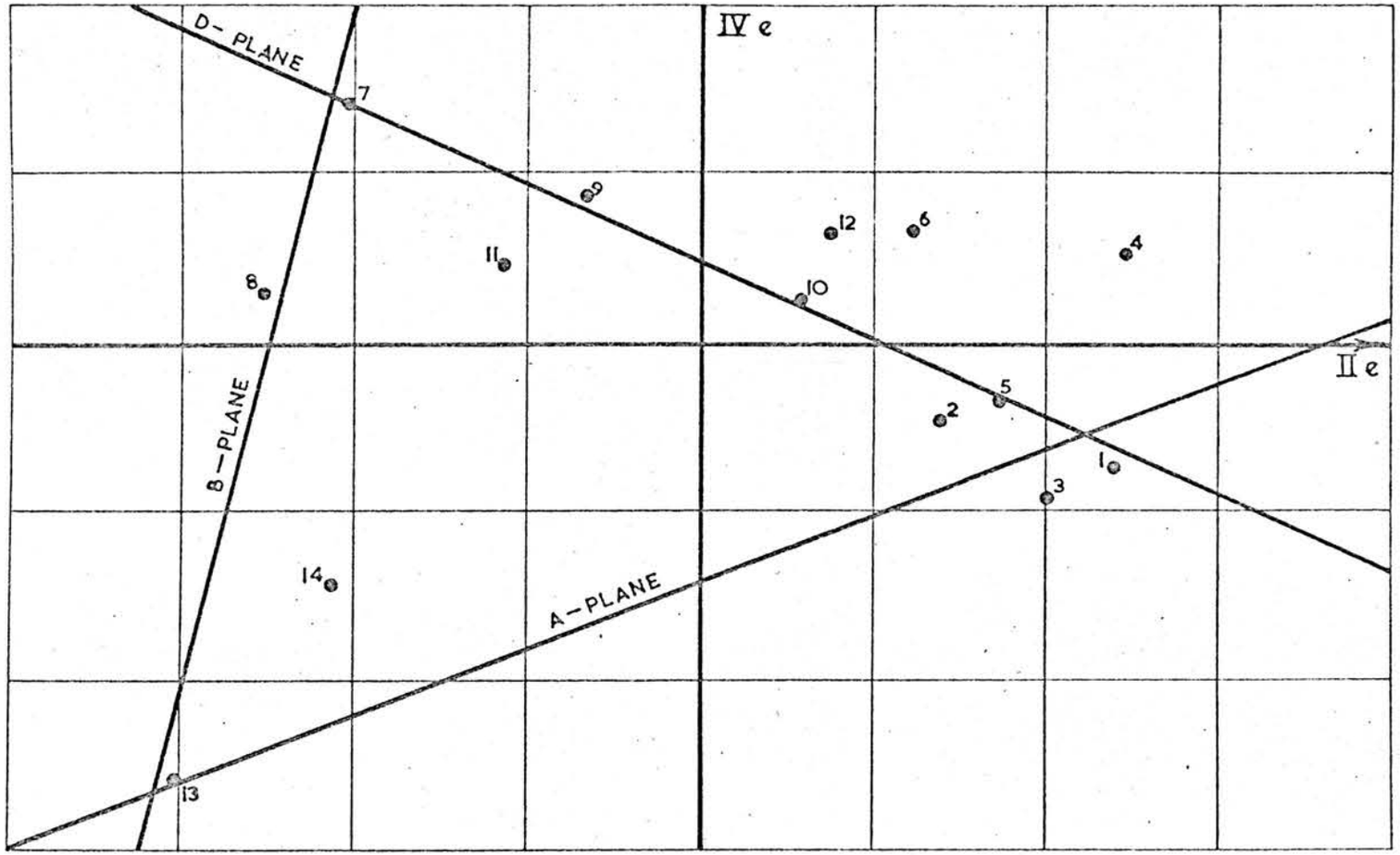

Fig. 18 FACTORS II e & IV e — BOYS

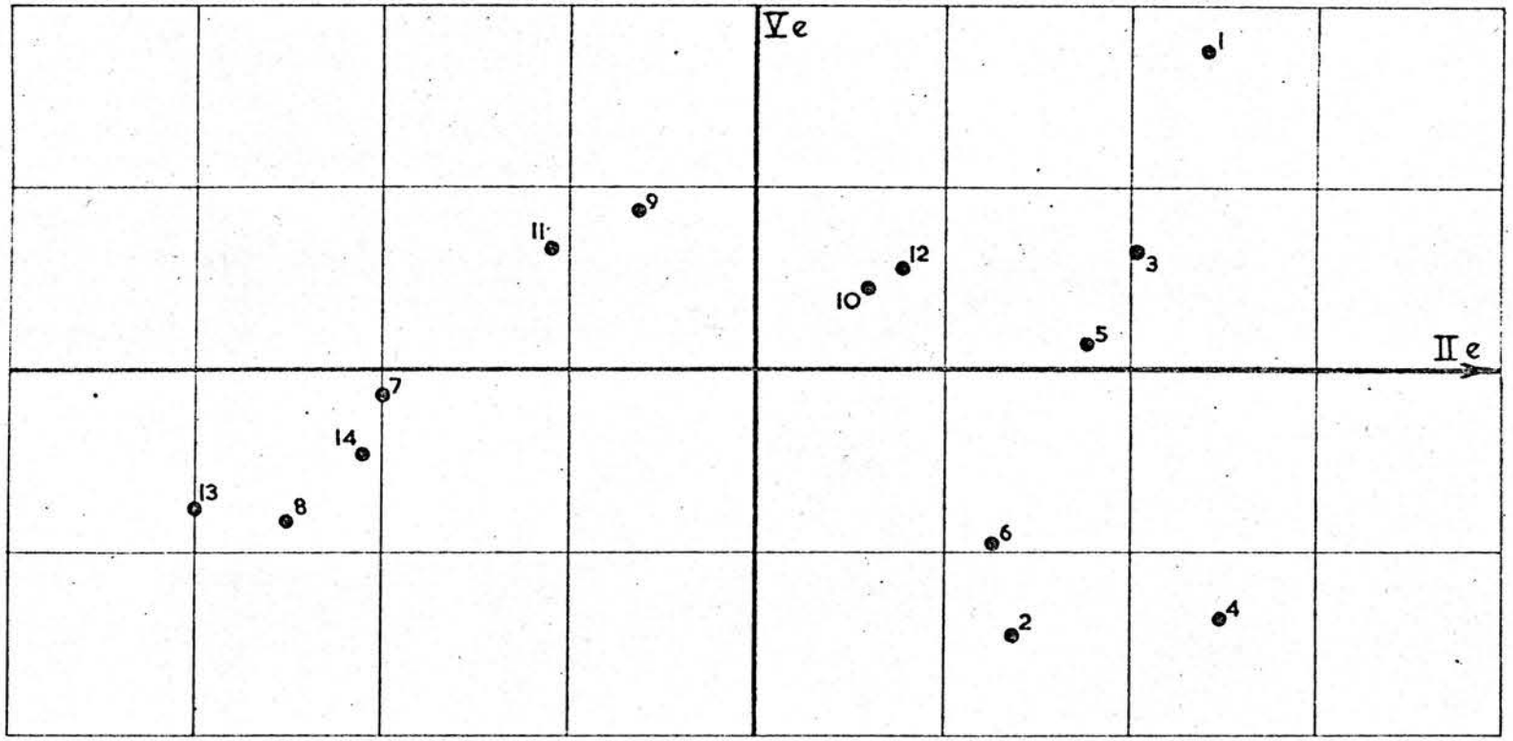

Fig. 19 FACTORS IIe & Ve —— BOYS

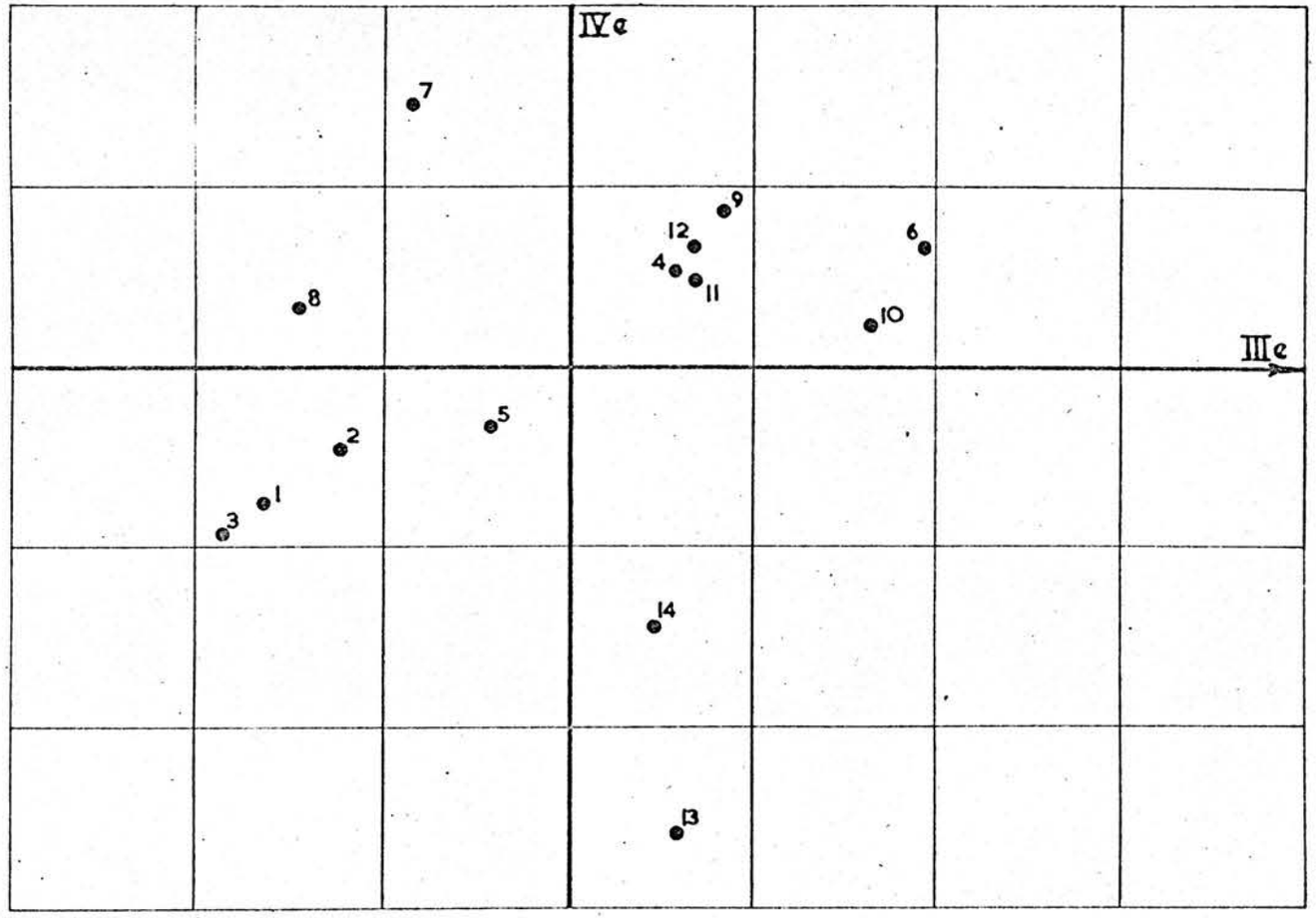

Fig. 20 FACTORS IIIe & IVe — BOYS

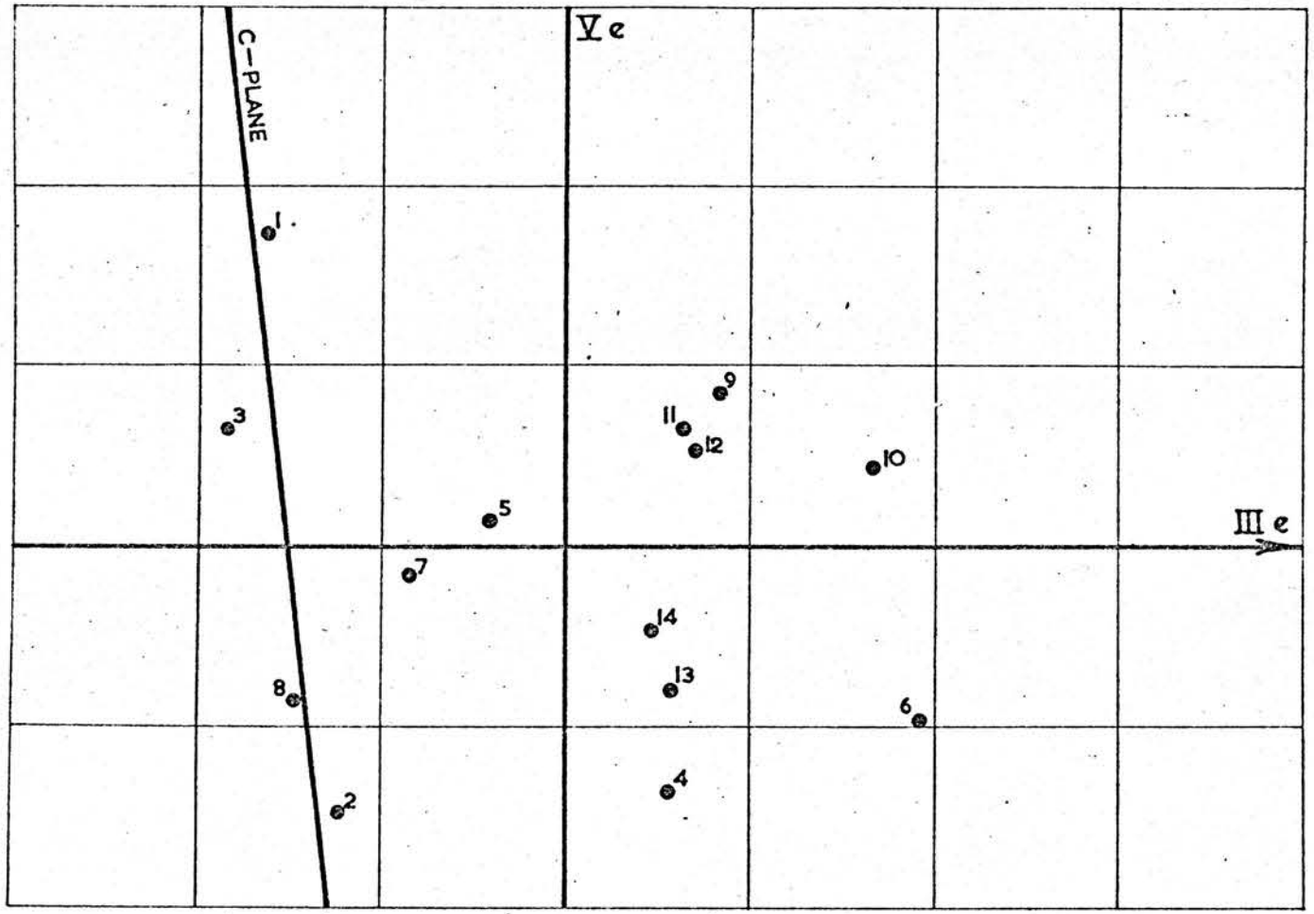

Fig. 21 FACTORS IIIe & Ve — BOYS

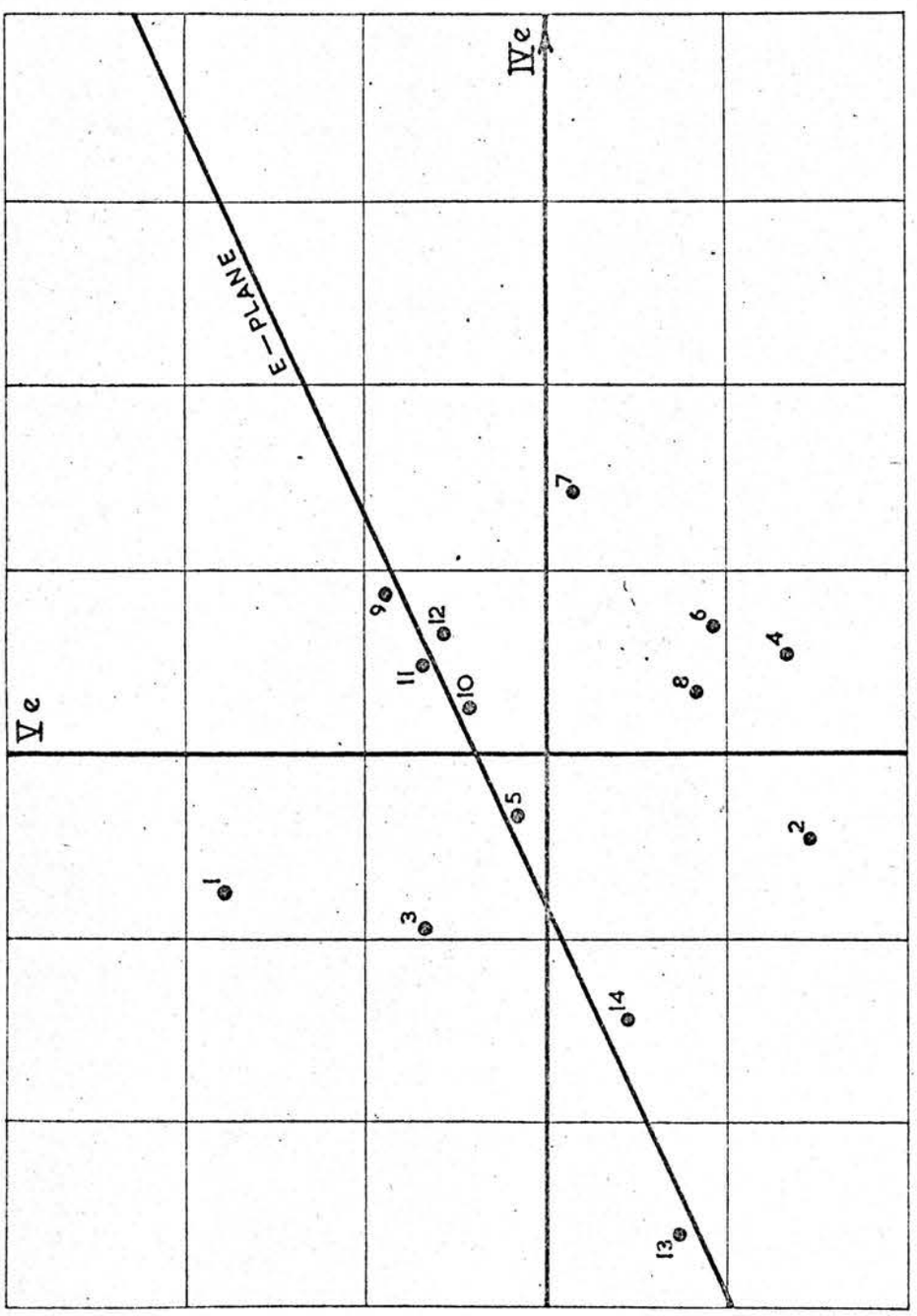

Fig. 22 FACTORS IVe & Ve —— BOYS

It will be seen that planes A, B and D were defined with respect to the same three axes, namely, I_e, II_e and IV_e (Figure 18). The C-plane was defined with respect to the axes I_e, III_e and V_e (Figure 21) and the E-plane with respect to I_e, IV_e and V_e (Figure 22).

We will now discuss the reasons why each particular line was chosen.

(i) The B-plane.

For the B-plane it is desirable to select a line which makes a large angle (approaching a right angle) with axis II_e[58]. Three alternative lines were considered, namely, 3, 5, 6, in Figure 17, 7, 8, 13 in Figure 18 and 1, 3, 2 in Figure 19. The second of these alternatives was chosen since it is the longest line and bounds the configuration. It is not an ideal line since it has only three points to define it. However, the fact that the same line appears in the girls' data (Figure 28) gives us greater confidence in our choice.

(ii) The C-plane.

For this plane it is desirable to select a line which makes a large angle with axis III_e. Again three alternatives were considered, namely line 4, 11, 13 in Figure 17, line 7, 5, 13 in Figure 20 and line 1, 3, 8, 2 in Figure 21. The first line is the

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58. G.H. Thomson, The Factorial Analysis of Human Ability, p. 259.

longest and passes through most points, but it has the disadvantage which it shares with the second, that it does not bound the configuration. For this reason, the latter alternative was preferred.

(iii) The D-plane.

For this plane, we seek a line which makes a large angle with axis IV_e. Two alternatives were considered, namely the lines 7, 6, 4 and 7, 10, 5, both in Figure 18. The latter was chosen, since it is the longer line. We note that points 7, 10, 5 define what is apparently the same line for the girls (Figure 28).

(iv) The E-plane.

For this plane, we seek a line which makes a large angle with axis V_e. Two alternatives were considered, namely line 13, 8, 4 in Figure 19 and line 13, 5, 9 in Figure 22. The better choice here would have been the former line. This became clear at the next stage in the rotation and the line was changed (Figure 23, fourth drawing).

(v) The A-plane.

When selecting a line for the A-plane, care must be taken to ensure that one does not merely duplicate one of the lines already chosen; for it frequently happens that the same plane is represented by collinear points in more than one diagram. Some difficulty was experienced in obtaining a suitable line for this plane and consequently it was decided

to allow psychological considerations to determine the choice. The line selected (Figure 18) was intended to yield a verbal factor not already obtained. This introduction of the subjective element into our calculations may be justified on the grounds that in a relatively small battery such as ours, we have insufficient tests to completely determine the "simple structure". A line corresponding to the one we have chosen was objectively discovered in the girls' data (Figure 28) and this substantiates our results.

We now record the equations of the lines. In Thurstone's notation, they are:-

$$A_2^1 = 1.000\ IV - .380\ II + .355\ I$$
$$B_2^1 = 1.000\ II - .255\ IV + .625\ I$$
$$C_2^1 = 1.000\ III + .120\ V + .385\ I$$
$$D_2^1 = 1.000\ IV - .460\ II + .125\ I$$
$$E_2^1 = 1.000\ V + .475\ IV + .095\ I$$

The coefficients of these equations are written in the appropriate columns of matrix S_{01} given below. The calculations then follow the formula given at the top of each table. In the initial positioning of the reference axes, matrix L_{01} is identical with S_{01} and Λ_{01} with H_{01}. For the subsequent rotations they are different. $\Sigma 1^2$ is obtained by summing the squares of the column entries, and D_1 is the reciprocal of $\sqrt{\Sigma 1^2}$. The direction cosines of the angles separating the first positions of the reference vectors are given in matrix C_1.

Matrix S_{01}

	I	A_2^1	B_2^1	C_2^1	D_2^1	E_2^1
I	1.000	.355	.625	.385	.125	.095
II		-.380	1.000		-.460	
III				1.000		
IV		1.000	-.255		-1.000	.475
V				.120		-1.000

Matrix $L_{01} = S_{01}$

	I	A_2^1	B_2^1	C_2^1	D_2^1	E_2^1
I	1.000	.355	.625	.385	.125	.095
II		-.380	1.000		-.460	
III				1.000		
IV		1.000	-.255		-1.000	.475
V				.120		-1.000
$\sum 1^2$		1.2704	1.4557	1.1626	1.2272	1.2347
$\sqrt{\sum 1^2}$		1.1271	1.2065	1.0782	1.1078	1.1112
D_1		.8872	.8288	.9275	.9027	.8999

Matrix $H_{01} = S_{01}\ D_1$

	I	A_2	B_2	C_2	D_2	E_2
I	1.000	.315	.518	.357	.113	.085
II		-.337	.829		-.415	
III				.928		
IV		.887	-.211		-.903	.427
V				.111		-.900

Matrix $\Lambda_{01} = L_{01}\ D_1$

	I	A_2	B_2	C_2	D_2	E_2
I	1.000	.315	.518	.357	.113	.085
II		-.337	.829		-.415	
III				.928		
IV		.887	-.211		-.903	.427
V				.111		-.900

Matrix $E_1 = E_0 H_{01}$

	I	A	B	C	D	E
1	1.000	-.051	1.051	.026	.034	-.390
2	1.000	.097	.827	.029	.075	.372
3	1.000	-.062	.983	-.060	.117	-.168
4	1.000	.221	1.005	.454	-.262	.445
5	1.000	.097	.892	.263	.009	.014
6	1.000	.358	.742	.777	-.168	.374
7	1.000	.800	.025	.147	.002	.273
8	1.000	.595	-.021	-.005	.306	.303
9	1.000	.571	.327	.569	-.016	-.014
10	1.000	.320	.622	.745	.001	.011
11	1.000	.517	.259	.519	.122	-.020
12	1.000	.398	.638	.526	-.114	.026
13	1.000	-.008	.032	.473	1.011	-.015
14	1.000	.177	.154	.454	.655	.043

Matrix $C_1 = \Lambda_{01} \Lambda_{01}$

	I	A	B	C	D	E
I	1.000					
A	.315	1.000				
B	.518	-.303	1.000			
C	.357	.112	.185	1.000		
D	.113	-.626	-.095	.040	1.000	
E	.085	.406	-.046	-.070	-.376	1.000

The next step is to plot the columns A, B, C, D and E of matrix E_1 in pairs. This gives ten diagrams. However, as only four were used in deciding the first adjustments to the reference axes, these are the only ones reproduced in Figure 23.

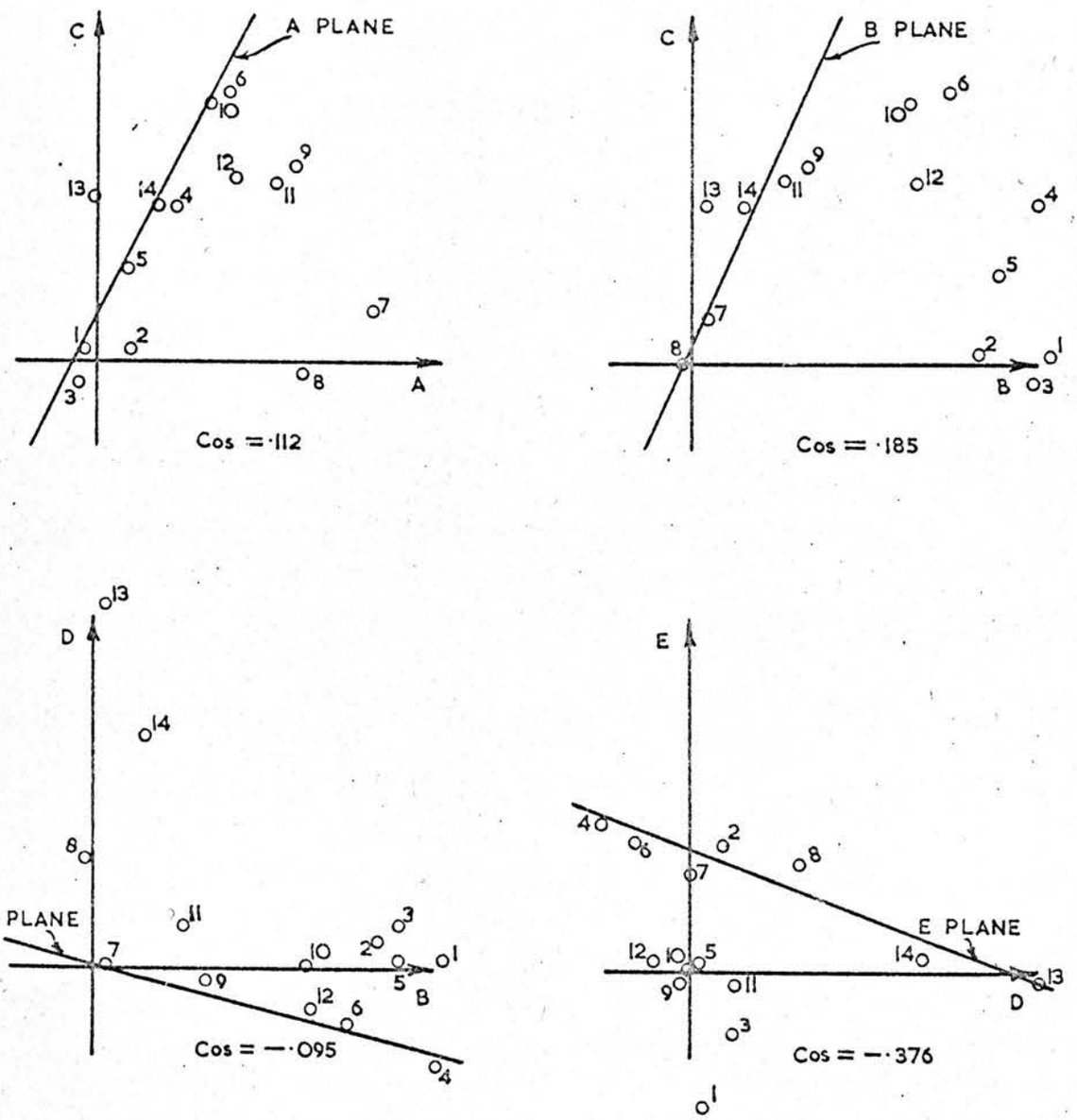


Fig. 23 DIAGRAMS SHOWING FIRST ADJUSTMENTS TO REFERENCE AXES —— BOYS

Having determined the equations of the new lines and recorded their coefficients in matrix S_{12}, the calculations are continued as before.

Matrix S_{12}

	I	A_2^1	B_2^1	C_2^1	D_2^1	E_2^1
I	1.000	.060	.030		-.015	.350
A_1		1.000				
B_1			1.000		.260	
C_1		-.520	-.450	1.000		
D_1					1.000	-.380
E_1						-1.000

Matrix $L_{C2} = \Lambda_{01} S_{12}$

	I	A_2^1	B_2^1	C_2^1	D_2^1	E_2^1
I	1.000	.189	.387	.357	.233	.222
II		-.337	.829		-.199	.158
III		-.483	-.418	.928		
IV		.887	-.211		-.958	-.084
V		-.058	-.050	.111		.900
$\frac{\Sigma 1^2}{\sqrt{\Sigma 1^2}}$		1.1727	1.0588	1.0010	1.0117	.8913
		1.0829	1.0290	1.0000	1.0058	.9441
D_2		.9234	.9718	1.0000	.9942	1.0592

Matrix $H_{12} = S_{12} D_2$

	I	A_2	B_2	C_2	D_2	E_2
I	1.000	.055	.029		-.015	.371
A_1		.923				
B_1			.972		.258	
C_1		-.480	-.437	1.000		
D_1					.994	-.402
E_1						-1.059

Matrix $\Lambda_{02} = L_{02} D_2$

	I	A_2	B_2	C_2	D_2	E_2
I	1.000	.175	.376	.357	.232	.235
II		-.311	.806		-.198	.167
III		-.446	-.406	.928		
IV		.819	-.205		-.952	-.089
V		-.054	-.049	.111		.953

Matrix $E_2 = E_1 H_{12}$

	I	A	B	C	D	E
1	1.000	-.004	1.039	.026	.290	.770
2	1.000	.131	.820	.029	.273	-.053
3	1.000	.027	1.011	-.060	.355	.502
4	1.000	.041	.807	.454	-.016	.005
5	1.000	.018	.781	.263	.224	.353
6	1.000	.012	.411	.777	.009	.042
7	1.000	.723	-.011	.147	-.007	.081
8	1.000	.607	.011	-.005	.284	-.073
9	1.000	.309	.098	.569	.053	.392
10	1.000	-.007	.308	.745	.146	.359
11	1.000	.283	.054	.519	.173	.343
12	1.000	.170	.419	.526	.036	.389
13	1.000	-.179	-.147	.473	.998	-.020
14	1.000	.000	-.020	.454	.676	.062

Matrix $C_2 = \Lambda_{02}^{1} \Lambda_{02}$

	I	A	B	C	D	E
I	1.000					
A	.175	1.000				
B	.376	-.169	1.000			
C	.357	-.357	-.248	1.000		
D	.232	-.678	.123	.083	1.000	
E	.235	-.135	.195	.190	.106	1.000

The second adjustments to the reference axes are made after consulting the ten diagrams obtained by plotting the columns of matrix E_2. As before only four are reproduced (Figure 24).

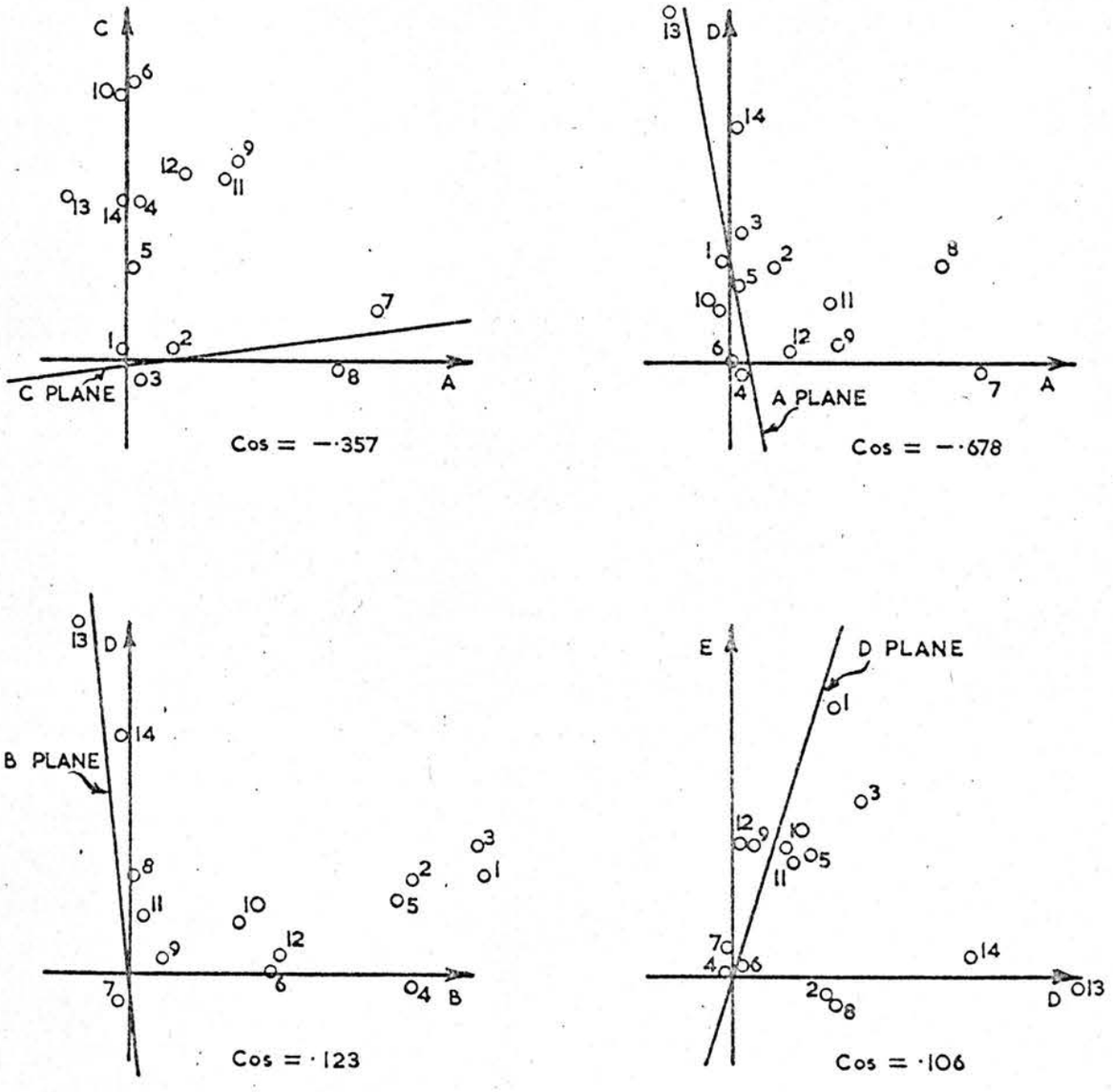


Fig. 24 DIAGRAMS SHOWING SECOND ADJUSTMENTS TO REFERENCES AXES — BOYS

The third rotation follows the same pattern as before.

Matrix S_{23}

	I	A_2^1	B_2^1	C_2^1	D_2^1	E_2^1
I	1.000	-.035	-.010	.010	.020	
A_1		1.000		-.130		
B_1			1.000			
C_1				1.000		
D_1		.140	.120		1.000	
E_1					-.310	1.000

Matrix $L_{03} = \Lambda_{02} S_{23}$

	I	A_2^1	B_2^1	C_2^1	D_2^1	E_2^1
I	1.000	.172	.394	.344	.179	.235
II		-.339	.782	.040	-.250	.167
III		-.446	-.406	.986		
IV		.686	-.319	-.106	-.924	-.089
V		-.054	-.049	.118	-.295	.953
$\sum l^2$		.8169	1.0358	1.1173	1.0353	.9992
$\sqrt{\sum l^2}$		.9038	1.0177	1.0570	1.0175	1.0000
D_3		1.1064	.9826	.9461	.9828	1.0000

Matrix $H_{23} = S_{23} D_3$

	I	A_2	B_2	C_2	D_2	E_2
I	1.000	-.039	-.010	.009	.020	
A_1		1.106		-.123		
B_1			.983			
C_1				.946		
D_1		.155	.118		.983	
E_1					-.305	1.000

Matrix $\Lambda_{03} = L_{03} D_3$

	I	A_2	B_2	C_2	D_2	E_2
I	1.000	.190	.387	.325	.176	.235
II		-.375	.768	.038	-.246	.167
III		-.493	-.399	.933		
IV		.759	-.313	-.100	-.908	-.089
V		-.060	-.048	.112	-.290	.953

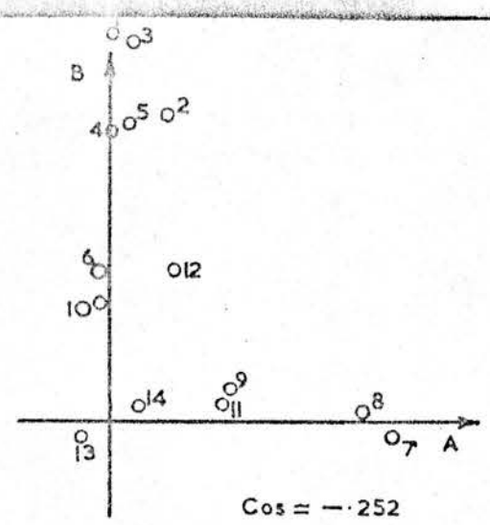
Matrix $E_3 = E_2 H_{23}$

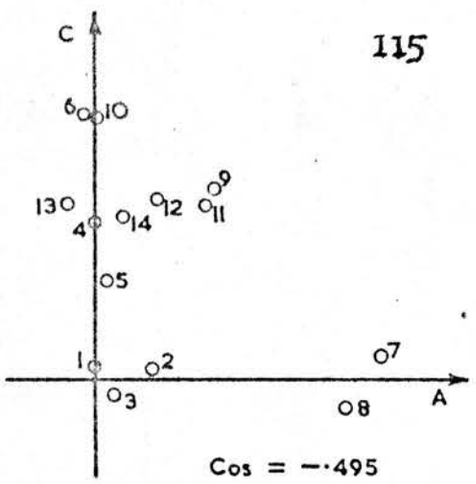
	I	A	B	C	D	E
1	1.000	-.002	1.045	.034	.071	.770
2	1.000	.148	.828	.020	.304	-.053
3	1.000	.046	1.026	-.051	.216	.502
4	1.000	.004	.781	.433	.003	.005
5	1.000	.016	.784	.256	.133	.353
6	1.000	-.024	.395	.743	.016	.042
7	1.000	.760	-.022	.059	-.012	.081
8	1.000	.676	.034	-.070	.321	-.073
9	1.000	.311	.093	.509	-.047	.392
10	1.000	-.024	.310	.715	.054	.359
11	1.000	.301	.063	.465	.085	.343
12	1.000	.155	.406	.486	-.063	.389
13	1.000	-.082	-.037	.478	1.007	-.020
14	1.000	.066	.050	.438	.666	.062

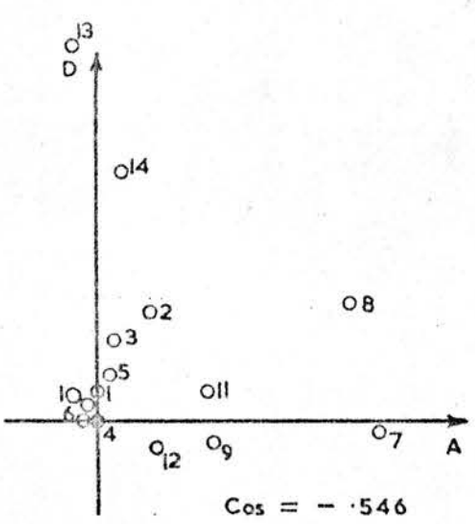
Matrix $C_3 = \Lambda_{03} \Lambda_{03}$

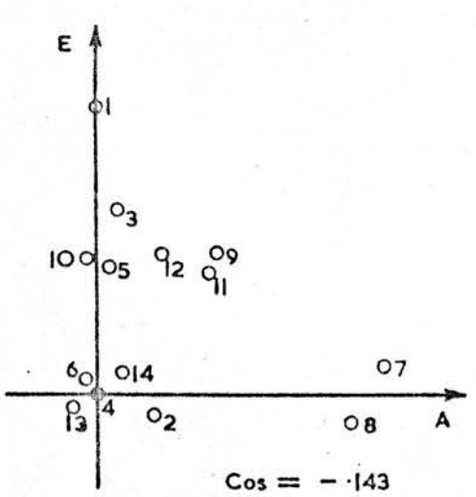
	I	A	B	C	D	E
I	1.000					
A	.190	1.000				
B	.387	-.252	1.000			
C	.325	-.495	-.191	1.000		
D	.176	-.546	.177	.106	1.000	
E	.235	-.143	.201	.198	-.195	1.000

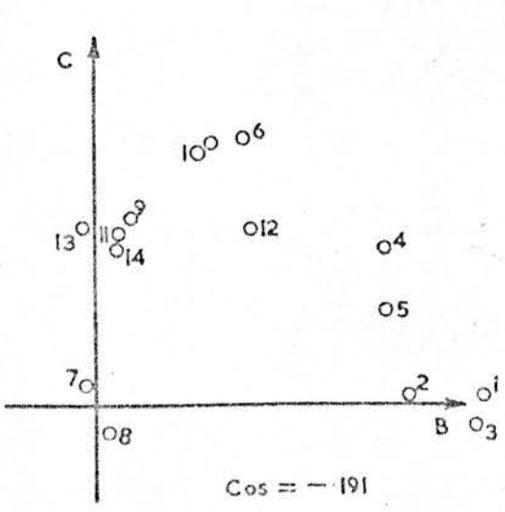
No further adjustments are suggested by the diagrams obtained from matrix E_3 which therefore show the configuration in relation to the final positions of the reference axes. The drawings are shown in Figure 25.











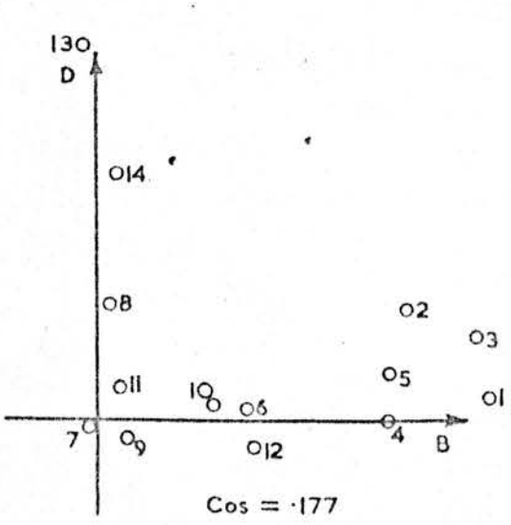


Fig.25 DIAGRAMS SHOWING THE CONFIGURATION RELATIVE TO THE CHOSEN REFERENCE AXES —— BOYS

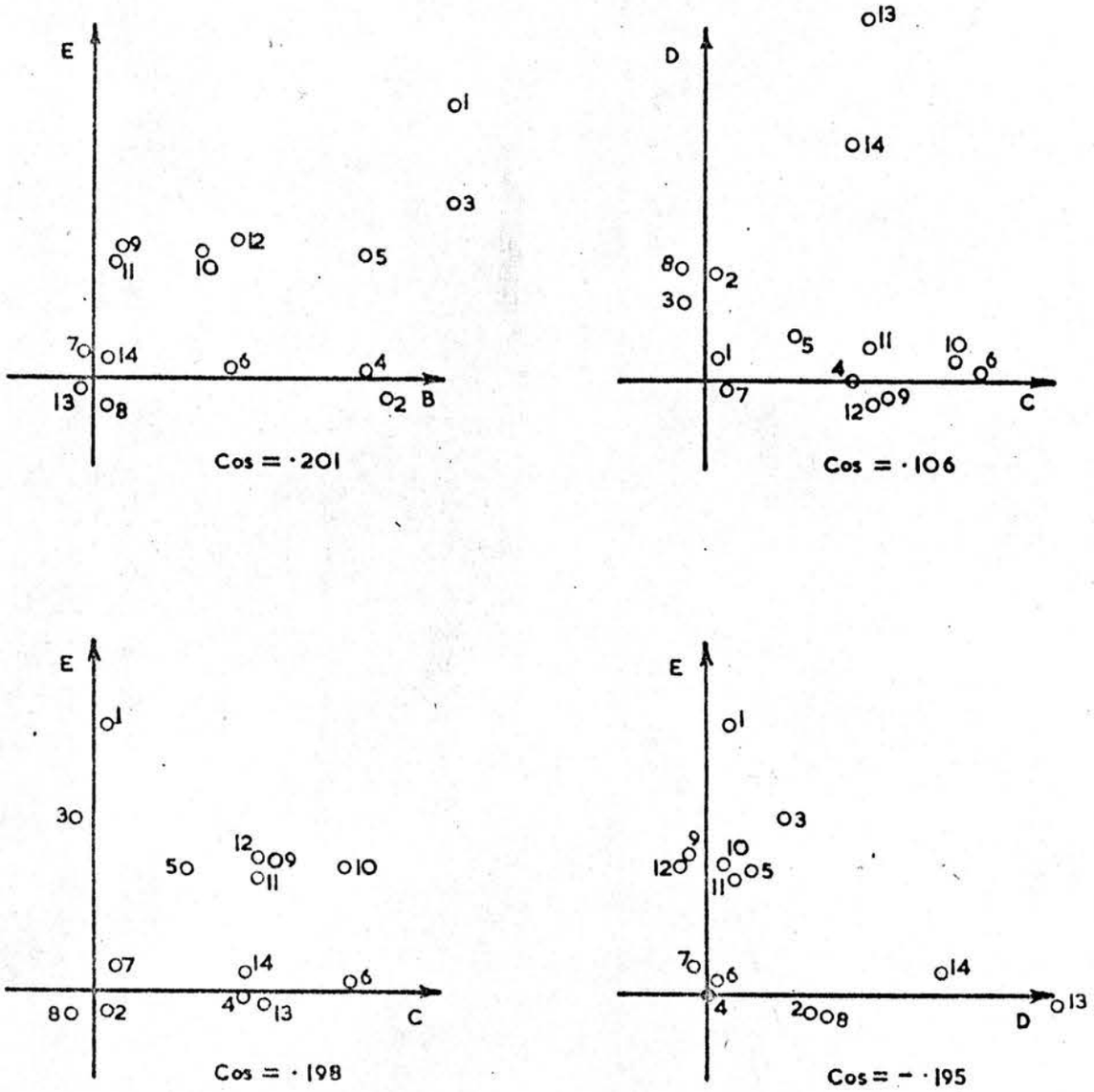


Fig. 25 (Continucd)

At this stage there is an independent check on our calculations. If we post-multiply matrix E_0 of Table XVIII by matrix Δ_{03}, we get matrix E_3 which we have already computed from the formula $E_3 = E_2 H_{23}$.

By post-multiplying the centroid matrix F_0 of Table XVI by matrix Λ_{03}, we get matrix V_3 which gives the simple structure on the reference vectors. This is checked by converting the test vectors of matrix E_3 to their normal length (by multiplying each row by the corresponding first centroid loading). Matrix V_3 which is used for interpretation purposes is given in Table XIX. From matrix C_3, we obtain the angles between the reference vectors as well as the angles between these vectors and the first centroid axes. They are recorded in Table XX.

TABLE XIX. SIMPLE STRUCTURE ON THE REFERENCE VECTORS - BOYS.

$V_4 = F \Lambda_{03}$

Test.	A	B	C	D	E
1. Space 1/R	.000	.588	.019	.040	.433
2. Space 2/R	.086	.478	.012	.176	-.031
3. Space 3/R	.033	.741	-.038	.157	.363
4. Space 4/R	.003	.412	.228	.002	.003
5. Space 5/R	.011	.558	.182	.095	.251
6. Space 6/R	-.015	.252	.473	.011	.027
7. Synonyms	.579	-.016	.045	-.008	.061
8. Word Formation	.489	.025	-.051	.232	-.053
9. Verbal Analogies	.243	.072	.396	-.036	.305
10. No. Letter Series	-.018	.237	.547	.042	.274
11. Word Series	.219	..046	.340	.063	.250
12. Non-verb. Intell., Jenkins	.123	.324	.387	-.049	.309
13. Mechanical Arithmetic	-.044	-.020	.258	.545	-.011
14. Problem Arithmetic	.051	.038	.335	.509	.047

TABLE XX

Angles between the Reference Vectors - Boys.

	I	A	B	C	D	E
I						
A	79°					
B	67°	105°				
C	71°	120°	101°			
D	80°	123°	80°	84°		
E	76°	98°	78°	79°	101°	

(b) Girls' Data.

In Table XXI we give the Extended Factorial Matrix and in Figures 27 - 32, the two-dimensional sections of the hyper-plane at right angles to the first centroid axis.

TABLE XXI EXTENDED FACTORIAL MATRIX E_o - GIRLS.

Test	I_e	II_e	III_e	IV_e	V_e
1. Space 1/R	1.0000	.5748	-.2440	.2579	.1280
2. Space 2/R	1.0000	.3923	-.1667	-.1530	-.3078
3. Space 3/R	1.0000	.4722	-.3981	.2051	-.1440
4. Space 4/R	1.0000	.7980	.1193	-.1614	.1480
5. Space 5/R	1.0000	.4258	.0671	-.1978	.1904
6. Space 6/R	1.0000	.4038	.3328	.0857	.0617
7. Synonyms	1.0000	-.6821	-.1153	.2891	.1336
8. Word Formation	1.0000	-.6244	-.2600	.0959	.2018
9. Verbal Analogies	1.0000	-.3090	.2135	.1189	-.0984
10. No. Letter Series	1.0000	.0669	.3142	-.0147	.1296
11. Word Series	1.0000	-.2502	.1137	-.0558	-.1390
12. Non-verb. Intell., Jenkins	1.0000	-.0291	.2428	.1734	-.0706
11. Mechanical Arithmetic	1.0000	-.5161	-.2584	-.3877	.0647
14. Problem Arithmetic	1.0000	-.3413	-.0881	-.2518	.1090

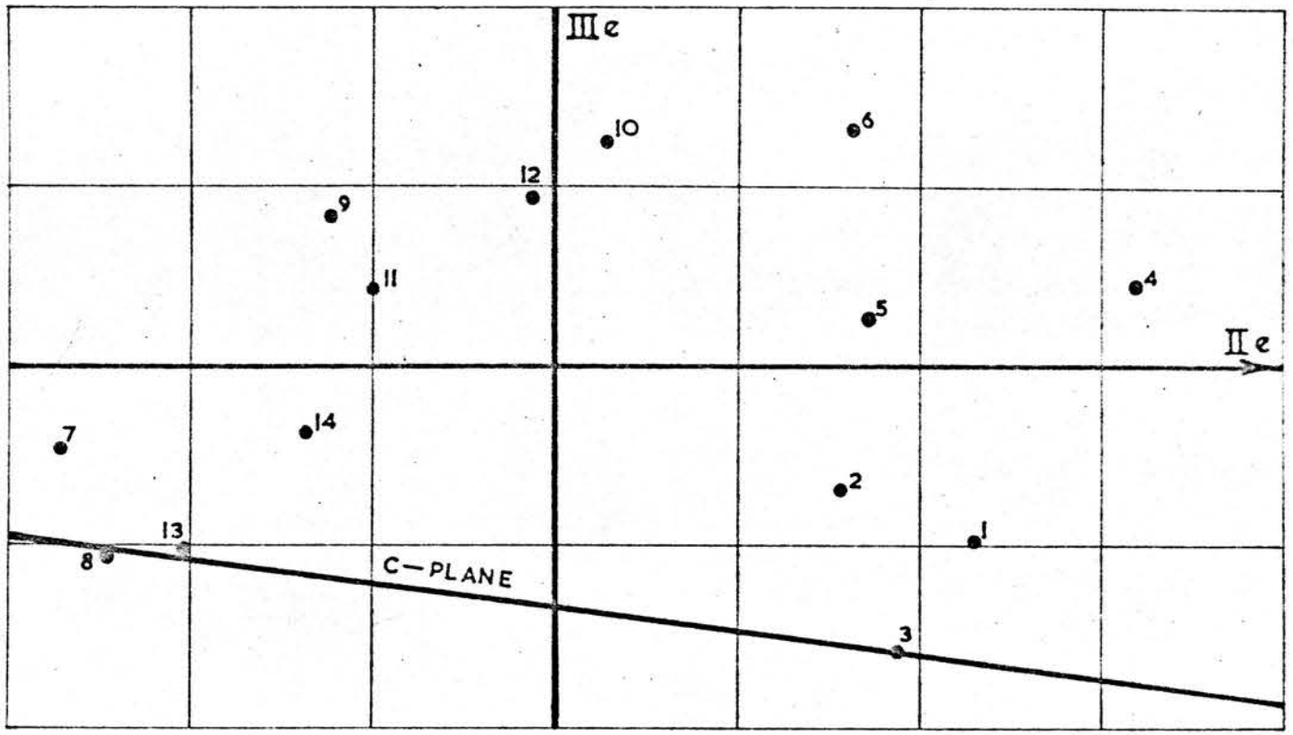


Fig. 27 FACTORS IIe & IIIe — GIRLS

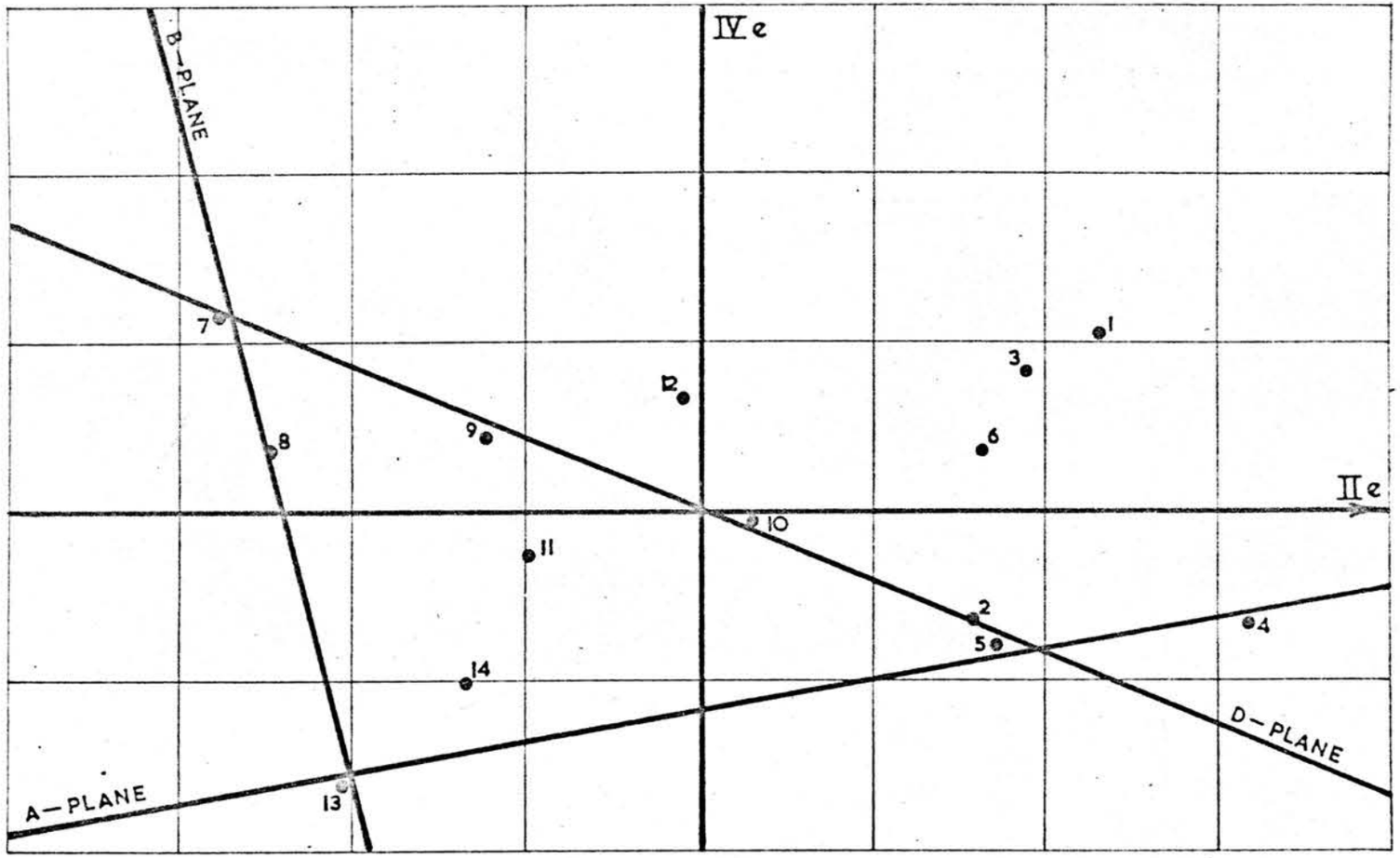


Fig. 28 FACTORS IIe & IVe — GIRLS

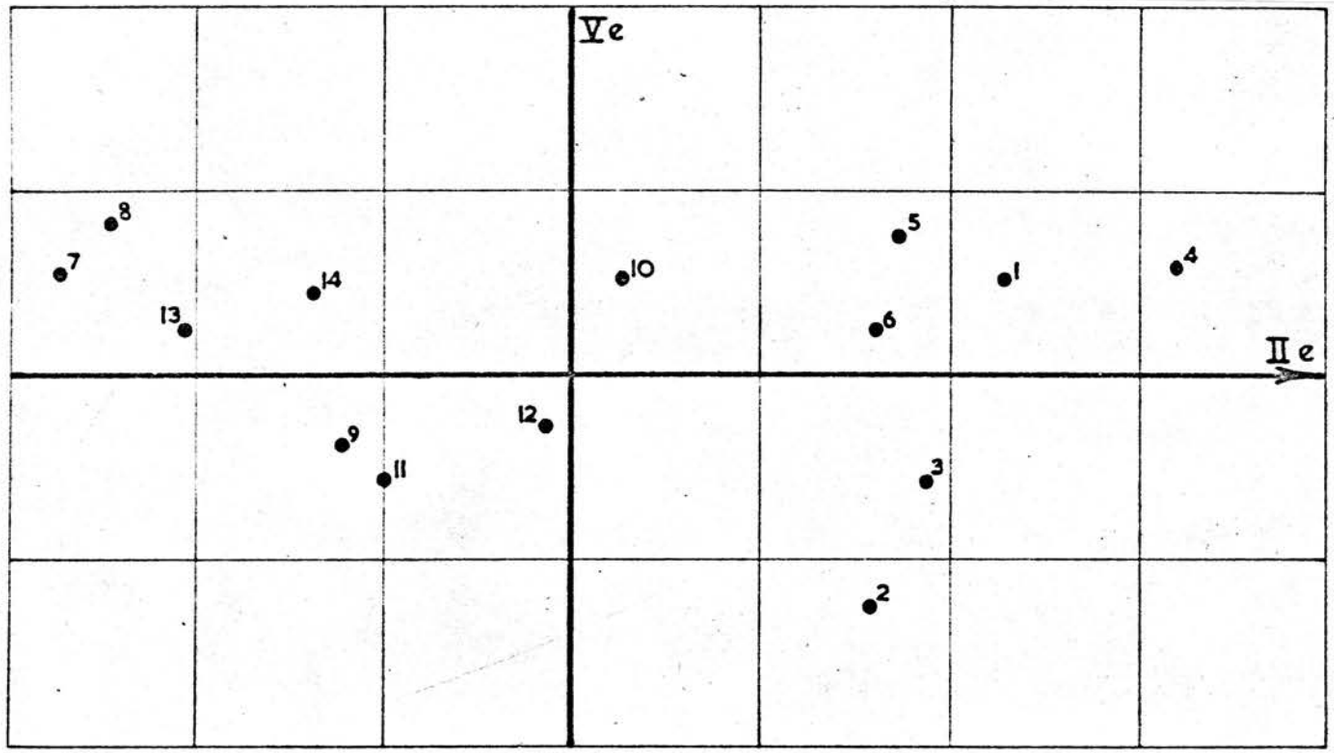


Fig. 29 FACTORS IIe & Ve — GIRLS

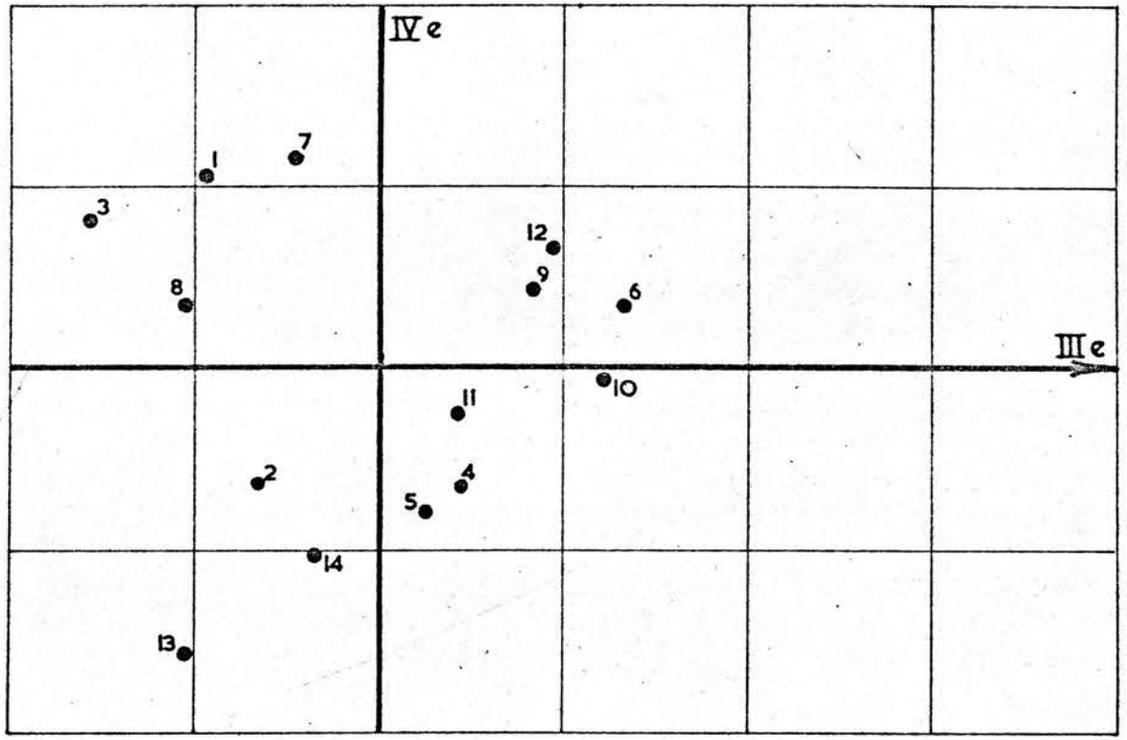


Fig. 30 FACTORS IIIe & IVe — GIRLS

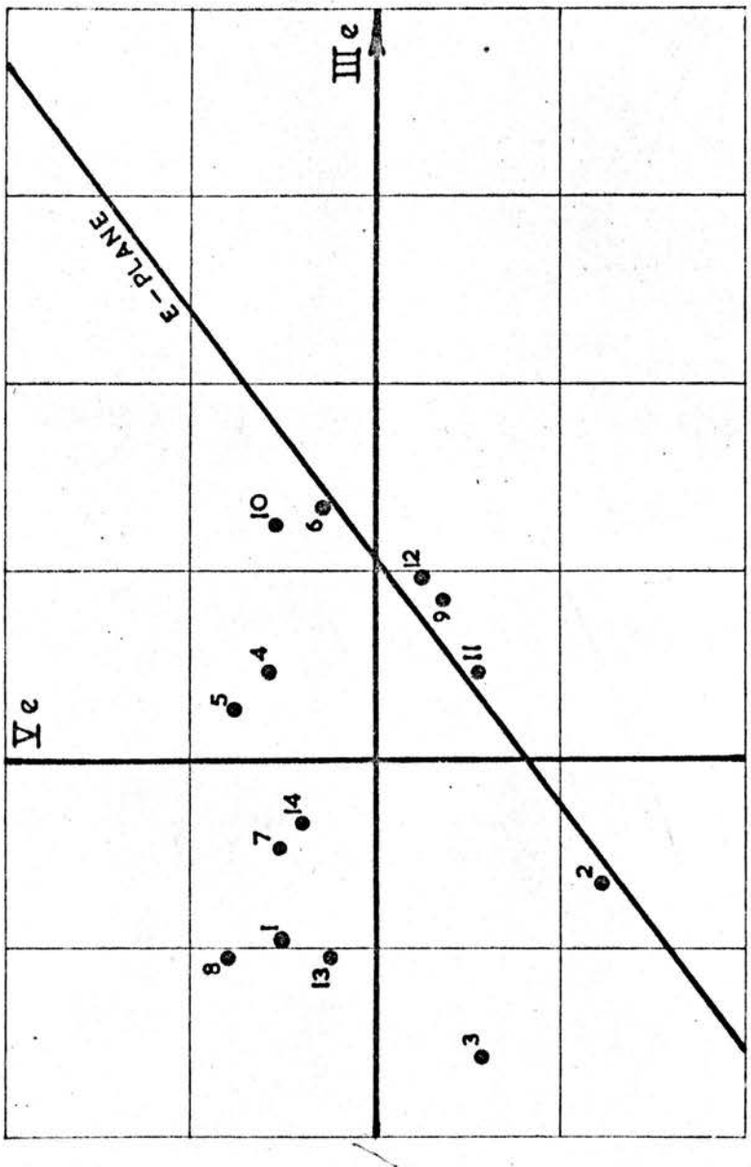


Fig. 31 FACTORS IIIe & Ve — GIRLS

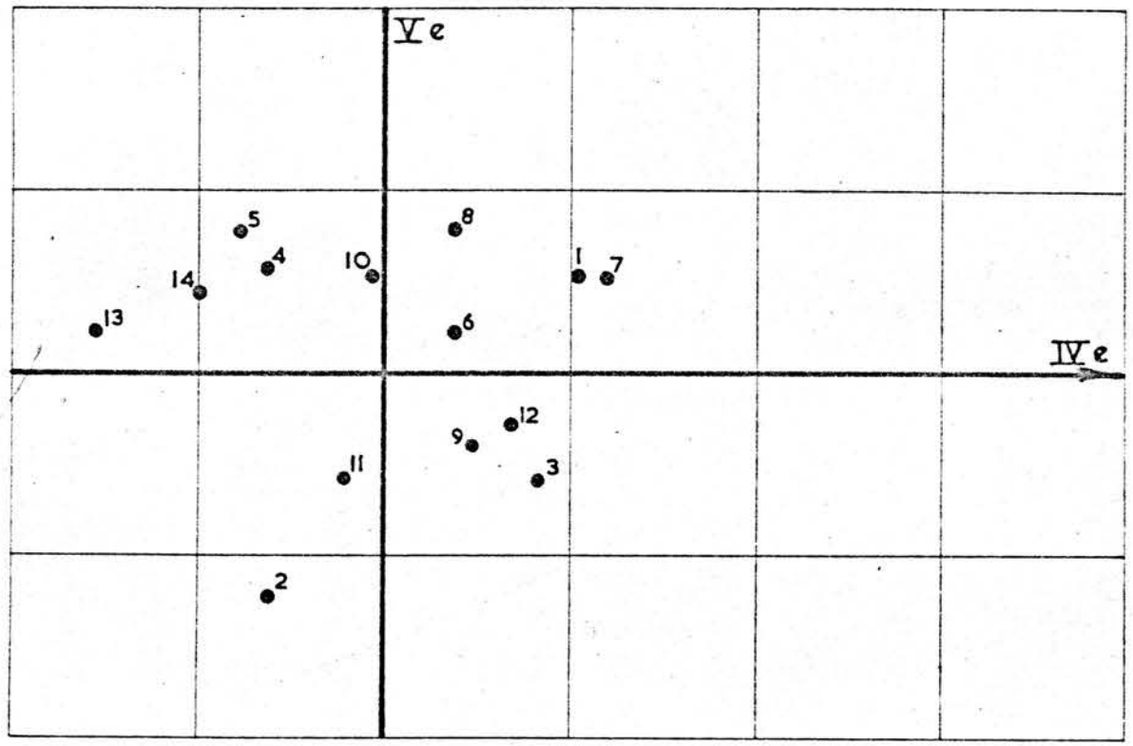


Fig. 32 FACTORS IVe & Ve — GIRLS

By comparing Figures 18 and 28, it will be seen that the planes A, B and D were defined in the same manner as in the boys' rotations. Two alternatives were considered for the C-plane, namely line 8, 13, 3 in Figure 27 and line 1, 8, 13 in Figure 30. However, since one merely duplicates the other it is immaterial which we choose. There is apparently no satisfactory line to determine the E plane (the thickness of the configuration for the fifth factor being very small) and as already indicated at the end of Chapter 6, difficulty was experienced in finding for it a suitable position.

The equations of the lines selected are given below.

$$A_2^1 = 1.000\ IV - .180\ II + .290\ I$$
$$B_2^1 = 1.000\ II + .260\ IV + .610\ I$$
$$C_2^1 = 1.000\ III + .135\ II + .335\ I$$
$$D_2^1 = -1.000\ IV - .420\ II + .005\ I$$
$$E_2^1 = 1.000\ V - .755\ III + .215\ I$$

The calculations were made as before, but this time four rotations were considered desirable. Details are omitted, but we give the rotating matrix Λ_{04} and matrix C_4 which gives the direction cosines of the angles between the reference vectors.

Matrix Λ_{04}

	I	A_2	B_2	C_2	D_2	E_2
I	1.000	.274	.295	.315	.238	.206
II		-.238	.706	.127	-.312	.345
III		.130	-.610	.941	-.326	-.506
IV		.906	.205		-.744	.128
V		-.172			.432	-.752

Matrix $C_4 = \Lambda_{04} \Lambda_{04}$

	I	A	B	C	D	E
I	1.000					
A	.274	1.000				
B	.295	.019	1.000			
C	.315	.178	-.391	1.000		
D	.238	-.651	-.104	-.271	1.000	
E	.206	.154	.639	-.367	-.314	1.000

By post-multiplying the centroid matrix F_0 of Table XVII by matrix Λ_{04}, we get matrix V_4 which gives the simple structure on the reference vectors. This is checked in the same way as before. Matrix V_4 which is used for interpretation purposes is given in Table XXII. From, matrix C_4, we obtain the angles between the reference vectors as well as the angles between these vectors and the first centroid axis. They are recorded in Table XXIII.

TABLE XXII SIMPLE STRUCTURE ON THE REFERENCE VECTORS - GIRLS

$V_4 = F \Lambda_{04}$

Test	A	B	C	D	E
1. Space 1/R	.190	.542	.095	.001	.279
2. Space 2/R	.051	.451	.146	.106	.448
3. Space 3/R	.248	.707	.000	.004	.545
4. Space 4/R	-.038	.399	.280	.071	.153
5. Space 5/R	-.023	.384	.323	.234	.112
6. Space 6/R	.190	.260	.448	-.022	.093
7. Synonyms	.478	-.041	.087	.239	-.025
8. Word Formation	.323	.024	-.007	.390	-.013
9. Verbal Analogies	.408	-.024	.389	.109	.066
10. No. Letter Series	.210	.118	.494	.145	-.023
11. Word Series	.269	.031	.327	.218	.134
12. Non-verb. Intell., Jenkins	.396	.133	.444	.007	.122
13. Mechanical Arithmetic	.001	.006	.004	.503	.038
14. Problem Arithmetic	.080	.047	.157	.504	.015

TABLE XXIII

Angles between Reference Vectors - Girls.

	I	A	B	C	D	E
I						
A	74°					
B	73°	89°				
C	72°	80°	113°			
D	76°	131°	96°	106°		
E	78°	81°	50°	112°	108°	

(2) The Primary Factors.

In tables XX and XXIII we have recorded the angles between the reference vectors and it will be seen that they depart from orthogonality. It follows, therefore, that the primary factors are oblique and distinct from the reference vectors. In order to ascertain the magnitude of the angles between the primary factors, we proceed as outlined below, the calculations being illustrated with the boys' data. For full details of the theory underlying the method, the reader is referred to "The Factorial Analysis of Human Ability".[59]

The first step is to determine the reciprocal of the matrix C_3[60], which gives the cosines of the angles between the reference vectors. This was done by

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59. Third Edition, pp. 283-4, 373-6.
60. Supra, p. 114.

Aitken's method of pivotal condensation and we obtained the following matrix:

$$\begin{bmatrix} 2.2996 & .5519 & 1.0863 & 1.0846 & .2142 \\ .5519 & 1.3269 & .5954 & -.0585 & -.3171 \\ 1.0863 & .5954 & 1.6718 & .2630 & -.2440 \\ 1.0846 & -.0585 & .2630 & 1.6603 & .4385 \\ .2142 & -.3171 & -.2440 & .4385 & 1.2282 \end{bmatrix} = C_3^{-1}$$

The square root of each diagonal cell of this matrix is then found, and its reciprocal entered in the diagonal matrix D given below:

$$\begin{bmatrix} .6594 & & & & \\ & .8681 & & & \\ & & .7734 & & \\ & & & .7761 & \\ & & & & .9024 \end{bmatrix} = D$$

By forming the matrix product $DC_3^{-1}D$ we get the cosines of the angles between the primary factors:

$$\begin{bmatrix} 1.000 & .316 & .554 & .555 & .127 \\ .316 & 1.000 & .400 & -.039 & -.248 \\ .554 & .400 & 1.000 & .158 & -.170 \\ .555 & -.039 & .158 & 1.000 & .307 \\ .127 & -.248 & -.170 & .307 & 1.000 \end{bmatrix} = DC_3^{-1}D$$

The angles are given in Table XXIV to the nearest degree.

TABLE XXIV.

Angles between the Primary Factors - Boys.

	A	B	C	D	E
A		72°	56°	56°	83°
B			66°	92°	104°
C				81°	100°
D					72°
E					

Likewise we find the cosines of the angles between the primary factors for the girls. They are:

$$\begin{bmatrix} 1.000 & .033 & .043 & .610 & .049 \\ .033 & 1.000 & .182 & -.013 & -.542 \\ .043 & .182 & 1.000 & .360 & .311 \\ .610 & -.013 & .360 & 1.000 & .354 \\ .049 & -.542 & .311 & .354 & 1.000 \end{bmatrix} = DC_4^{-1}D$$

The angles are given in Table XXV to the nearest degree.

TABLE XXV

ANGLES BETWEEN THE PRIMARY FACTORS - GIRLS.

	A	B	C	D	E
A		88°	88°	52°	87°
B			80°	91°	123°
C				69°	72°
D					69°
E					

Comments upon the magnitude of these angles will be reserved until we have discussed the nature of the different factors. Attention will here be drawn to the fact that we propose to use the reference vector structures of Tables XIX and XXII for interpretation purposes, the reason for this being, that although the primary factors and the reference vectors are different, the pattern on the primary factors (which gives the factor loadings) is identical with the structure on the reference vectors, except for a coefficient multiplying each column. These coefficients

are the reciprocals of the entries in diagonal matrix D. For the boys they are: 1.517, 1.152, 1.293, 1.288 and 1.108 for columns A, B, C, D and E respectively. For the girls they are 1.322, 1.334, 1.216, 1.479 and 1.447 in the same order.

or the sq. rt. of the diagonal entries of C_3^{-1} for boys & C_4^{-1} for girls.

(3) Interpreting the Factors.

The question arises as to whether we have presented the best fitting mathematical solutions for the given test configurations. Having seen that the simple structures are reasonably well defined, it is probable, in the light of Thurstone's tentative criteria for a unique simple structure, that an answer to the above question would be in the affirmative. However, since there is no method of proving this other than by trial and error, we will judge the efficacy of the solutions by the extent to which the factors they suggest are meaningful and in agreement with our psychological expectation. Boys' and girls' results will be interpreted separately and then an attempt will be made to draw a comparison.

(a) The Boys' Factors. See page 118

(i) Factor A.

The highest entries in column A relate to Tests 7 and 8, which are both sub-tests of the Moray House English test. Except for Tests 9 and 11, which are two sub-tests of the Moray House Verbal Intelligence test, the remaining entries are vanishingly small.

From this we may infer that the factor represented here is a verbal factor.

(ii) Factor B.

It is evident that the common element in column B is of a spatial character. Factor B will therefore be called the space factor. Here several points of interest arise. In the first place, we note that the factor is involved in both the two and three dimensional tests. Secondly, our attention is drawn to the relatively small projection on this reference axis of Test 6. It is smaller even than that of the Jenkins' test which is primarily an intelligence test, though we do expect this latter test to possess some spatial loading. There is a faint indication, based on averaging the coefficients, that the two dimensional tests are more closely linked with the space factor than the three dimensional tests. What is perhaps more suggestive however is the fact that the tests with the highest loadings in the factor are those in which the subject has to visualize the movement of objects, irrespective of whether they are two or three dimensional in character.

The presence of the space factor in Test 10 is rather unexpected. Admittedly its projection on this reference vector is small and probably scarcely significant, but on consulting the test, we find a plausible explanation which we will illustrate with two selected items. They are:

(3) ..... L M A N O A P Q A .....

(33) ..... X B C X D E F X G H I J .....

The groups of letters in each row form a spatial pattern, which, when discovered enables one to complete the series. If one visualizes the A's in the first example as standing out from the remaining letters, the solution is immediately obvious. In the second example, if one concentrates on the X's, the pattern of the series becomes clear at once. For many items in the test, particularly the number series, the above explanation does not hold, but it does hold for a sufficient number to make it a possible explanation of the spatial loading in this test.

(iii) Factor C.

The highest coefficient in column C is associated with Test 10, which according to Thurstone involves an inductive or reasoning factor. The present results seem to support this view, for if one considers the tests introspectively one finds on the one hand, that the tests with zeros in columns C namely 1, 2, 3, 7 and 8 are those which one would expect to demand little or no reasoning ability, while on the other, the tests with the highest coefficients, namely 10, 6, 9 and 12 are those which one would expect to demand most reasoning power.

We note that it is factor C, a reasoning and not a visual factor, which suggests a distinction between the two and three dimensional space tests.

This finding provides an explanation of the common element underlying the three dimensional part of Moray House Space Test 1 and Raven's Matrices reported in a previous study[61].

(iv) Factor D.

Column D has only two coefficients of appreciable magnitude and since both relate to arithmetic tests we may infer that the factor represented here is an arithmetical or numerical one. It will be called the number factor.

(v) Factor E.

There are no coefficients in column E large enough to enable one to name the underlying factor with confidence, indeed, the impression gained is that this column merely expresses the residual error.

On consulting Table XXIV, we find that the factors we have named are all positively correlated, with the exception of the number and space factors which are orthogonal to each other. We note that the correlations between the verbal, number, and reasoning factors are moderately large.

(b) The Girls' Factors and a Comparison.

There is a sufficiently close agreement between the first four columns of Tables XIX and XXII to suggest that the underlying factors are the same for

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61. Robertson, Op. Cit., p. 14.

both samples. On the other hand, there are discrepancies between corresponding pairs of angles in Tables XXIV and XXV which make it undesirable to compare the factors as they stand. In order to test the hypothesis that the factors are the same for both boys and girls, we might rotate each set of axes with the same rotating matrix, preferably the average matrix obtained from both samples. Alternatively we might apply the boys' rotating matrix to the girls' centroid matrix and vice versa, thus obtaining two comparisons. Yet another comparison might be obtained after extracting the second-order factors, for then the structures are made orthogonal. As a point of interest it was decided to rotate the girls' centroid axes using the boys' rotating matrix and the results are summarized below:

Test	A		B		C		D		E	
	B	G	B	G	B	G	B	G	B	G
1	.00	.17	.59	.50	.02	.07	.04	-.14	.43	.26
2	.09	.02	.48	.57	.01	.12	.18	.22	-.03	.02
3	.03	.29	.74	.66	-.04	-.05	.16	-.07	.36	.12
4	.00	-.16	.41	.53	.23	.26	.00	.04	.00	.28
5	.01	-.12	.56	.55	.18	.33	.10	.15	.25	.40
6	-.02	-.04	.25	.35	.47	.43	.01	-.01	.03	.23
7	.58	.52	-.02	-.14	.05	.13	-.01	.03	.06	.16
8	.49	.45	.03	-.02	-.05	.05	.23	.14	-.05	.23
9	.24	.24	.07	.03	.40	.40	-.04	.14	.31	.06
10	-.02	-.01	.24	.25	.55	.51	.04	.11	.27	.30
11	.22	.16	.05	.15	.34	.35	.06	.28	.25	.06
12	.12	.18	.32	.18	.39	.43	-.05	.04	.31	.12
13	-.04	.13	-.02	.13	.26	.07	.55	.40	-.01	.15
14	.05	.14	.04	.19	.34	.22	.51	.38	.05	.25

The indication given is that factors A, B, C and D are the same for both samples.

CHAPTER VIII.

SECOND-ORDER FACTORS.

The primary factors which we isolated in the last chapter were correlated. Possibly, therefore, by analysing their intercorrelations, we might obtain further factors which may be thought of as causing the obliquity of the primary factors. Factors arrived at in this way are called second-order factors. Particular interest centres in the second-order solution, since it has been offered as an attempt to reconcile various theories of intelligence, among them being Spearman's theory of a general intellective factor, Thurstone's theory of correlated multiple factors and Sir Godfrey Thomson's sampling theory.

A second-order analysis was carried out for our own experimental data and the details are given below.

(1) Boys' Analysis.

The matrix of intercorrelations between the primary factors[62], was analysed by the centroid method, using estimated communalities. After two factors had been extracted, the residuals were extremely small and it was not considered necessary to carry the analysis further. These two factors were next rotated, keeping them orthogonal. Particulars relating to the rotation are given in the following table and Figure 26.

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62. Supra p.131

Factor	Old loadings I	Old loadings II	New loadings I_1	New loadings II_1
1	.886	-.010	.517	.720
2	.313	.486	-.218	.535
3	.592	.414	.001	.722
4	.572	-.464	.708	.202
5	.112	-.558	.521	-.229
Multipliers	(.574	-.819	for I_1 loadings	
	(.819	.574	for II_1 loadings	

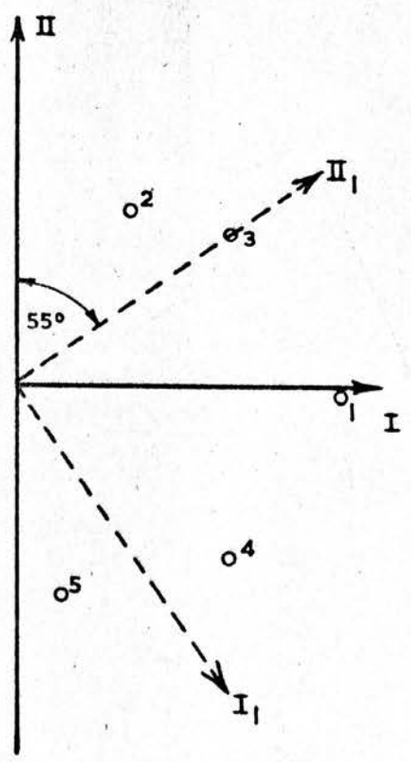

Fig. 26 DIAGRAM SHOWING ORTHOGONAL ROTATION OF SECOND ORDER FACTORS — BOYS

Following the procedure outlined by Sir Godfrey Thomson[63], we write these rotated loadings in matrix E, which is completed as indicated below, so that the sum of the squares in each row is unity.

$$\begin{bmatrix} .517 & .720 & .464 & & & \\ -.218 & .535 & & .816 & & \\ .001 & .722 & & & .692 & \\ .708 & .202 & & & & .676 \\ .521 & -.229 & & & & \end{bmatrix} = E$$

Premultiplying matrix E by the reciprocal of matrix D given in the previous chapter[64], i.e.

$$\begin{bmatrix} 1.5165 & & & & \\ & 1.1519 & & & \\ & & 1.2930 & & \\ & & & 1.2885 & \\ & & & & 1.1082 \end{bmatrix} = D^{-1}$$

we get:

$$\begin{bmatrix} .784 & 1.092 & .704 & & & \\ -.251 & .616 & & .940 & & \\ .001 & .934 & & & .895 & \\ .912 & .260 & & & & .871 \\ .577 & -.254 & & & & \end{bmatrix} = D^{-1}E$$

When matrix V_3 (in Table XIX) is postmultiplied by this, we obtain the analysis (given in Table XXVI) of the original fourteen tests into two general factors, plus an orthogonal simple structure of five factors.

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63. The Factorial Analysis of Human Ability, Third Edition, p. 301 - 2.
64. Supra, p.131

TABLE XXVI SECOND-ORDER FACTORS PLUS SIMPLE STRUCTURE - BOYS.

$$G = V D^{-1} E$$

Test	p.	q.	a.	b.	c.	d.	e.	Communality. Obtained	Communality. Centroid
1. Space 1/R	.139	.280	.000	.553	.017	.035	.394	.560	.554
2. Space 2/R	.090	.453	.061	.449	.011	.153	-.028	.443	.455
3. Space 3/R	.192	.406	.023	.697	-.034	.137	.331	.818	.814
4. Space 4/R	-.097	.470	.002	.387	.204	.002	.003	.422	.427
5. Space 5/R	.100	.487	.008	.525	.163	.083	.229	.609	.612
6. Space 6/R	-.049	.577	-.011	.237	.423	.010	.025	.571	.576
7. Synonyms.	.486	.647	.408	-.015	.040	-.007	.056	.826	.829
8. Word Formation.	.558	.576	.344	.024	-.046	.202	-.048	.805	.824
9. Verbal Analogies	.316	.593	.171	.068	.354	-.031	.278	.689	.708
10. No. Letter Series	.123	.579	-.013	.223	.490	.037	.250	.704	.702
11. Word Series	.362	.538	.154	.043	.304	.055	.228	.593	.612
12. Non-verb. Intell., Jenkins	.149	.604	.087	.305	.346	-.043	.281	.688	.704
13. Mechanical Arithmetic	.461	.325	-.031	-.019	.231	.475	-.010	.598	.598
14. Problem Arithmetic	.522	.512	.036	.036	.300	.443	.043	.825	.839
Sum of squares of loadings	1.377	3.699	.352	1.626	.973	.520	.597	9.150	9.255
Percentage of total variance	9.84	26.42	2.51	11.61	6.95	3.71	4.26	65.30	66.10

(2) Girls' Analysis.

The matrix of intercorrelations between the primary factors[65] was analysed by the centroid method. After two factors had been extracted, the residuals were very much larger than for boys and it was deemed necessary to extract a third factor. These factors were then rotated in pairs keeping them orthogonal. Details relating to the rotations are given in the following tables and Figure 33.

	Old loadings		New loadings	
	I	III	I_1	III_1
1	.389	-.355	.526	.017
2	-.310	.319	-.445	.012
3	.318	.468	-.099	.557
4	.800	-.145	.674	.455
5	.721	.174	.395	.628
Multipliers	.716	-.698	for I_1 loadings	
	.698	.716	for III_1 loadings	

	Old loadings		New loadings	
	I_1	II	I_2	II_1
1	.526	.387	.653	-.025
2	-.445	.625	.041	.767
3	-.099	.175	.032	.199
4	.674	.523	.854	-.010
5	.395	-.451	.028	-.599
Multipliers	.783	.623	for I_2 loadings	
	-.623	.783	for II_1 loadings	

65. Supra, p. 132

	Old loadings		New loadings	
	II_1	III_1	II_2	III_2
1	-.025	.017	-.017	.025
2	.767	.012	.716	-.277
3	.199	.557	.393	.442
4	-.010	.455	.161	.426
5	-.599	.628	-.320	.807
Multipliers	.927	.375	for II_2 loadings	
	-.375	.927	for III_2 loadings	

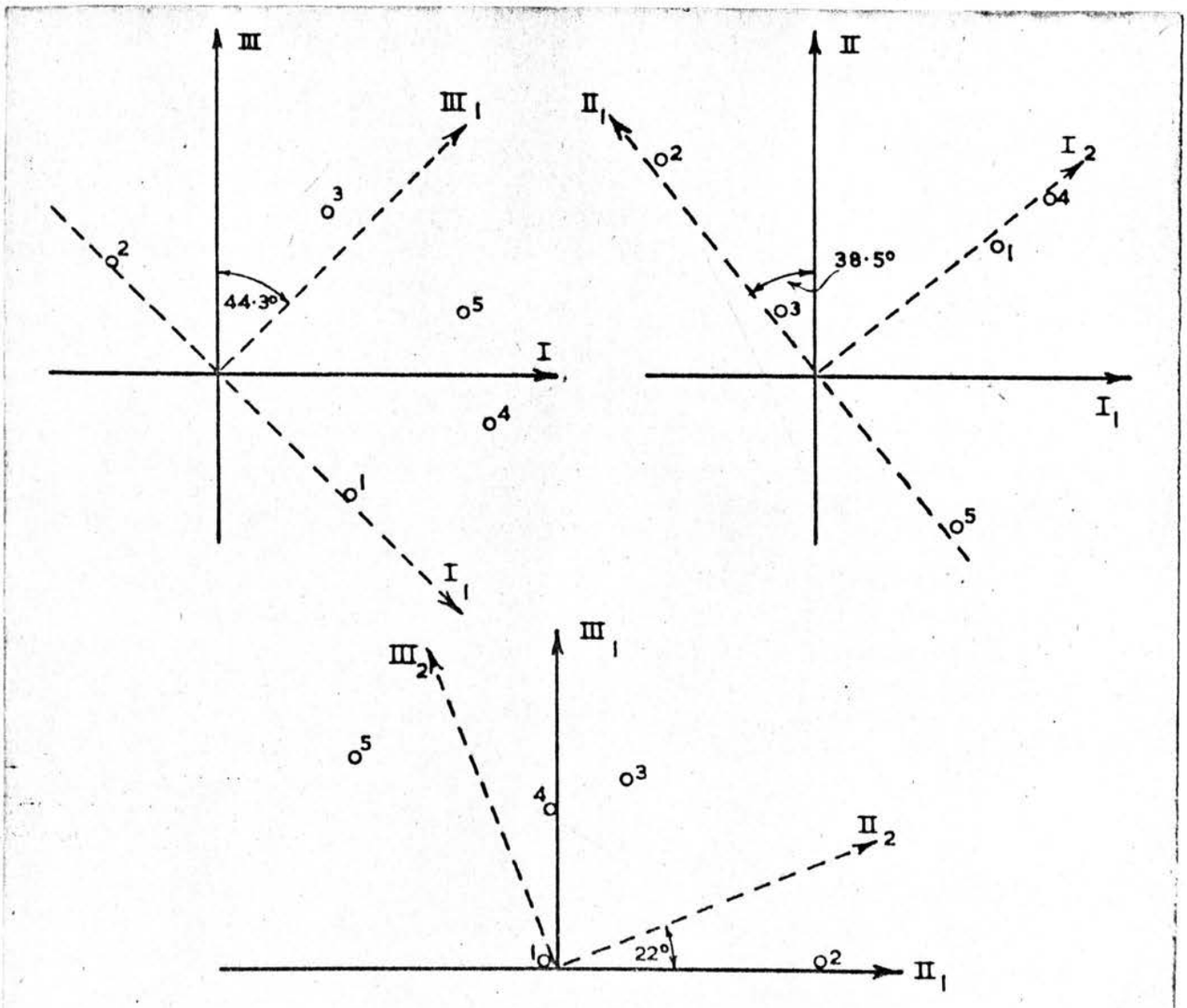


Fig. 33 DIAGRAMS SHOWING TWO-BY-TWO ROTATION OF SECOND ORDER FACTORS —— GIRLS

Matrix E is now completed as before.

$$\begin{bmatrix} .653 & -.017 & .025 & .757 & & & & \\ .041 & .716 & -.277 & & .641 & & & \\ .032 & .393 & .442 & & & .806 & & \\ .854 & .161 & .426 & & & & .256 & \\ .028 & -.320 & .807 & & & & & .496 \end{bmatrix} = E$$

Premultiplying this by reciprocal matrix D^{-1}, given below,

$$\begin{bmatrix} 1.3222 & & & & & \\ & 1.3344 & & & & \\ & & 1.2164 & & & \\ & & & 1.4786 & & \\ & & & & 1.4468 \end{bmatrix} = D^{-1}$$

we get:

$$\begin{bmatrix} .863 & -.022 & .033 & 1.001 & & & & \\ .055 & .955 & -.370 & & .855 & & & \\ .039 & .478 & .538 & & & .980 & & \\ 1.263 & .238 & .630 & & & & .379 & \\ .041 & -.463 & 1.168 & & & & & .718 \end{bmatrix} = D^{-1}E$$

When matrix V_4 (in Table XXII) is postmultiplied by this, we obtain the analysis (given in Table XXVII) of the original fourteen tests into three general factors, plus an orthogonal simple structure of five factors.

TABLE XXVII SECOND-ORDER FACTORS PLUS SIMPLE STRUCTURE - GIRLS.

$$G = V D^{-1} E$$

Test	p	q	r	a	b	c	d	e	Communality. Obtained	Communality. Centroid
1. Space 1/R	.210	.430	.183	.190	.463	.093	.000	.200	.562	.532
2. Space 2/R	.227	.317	.448	.051	.386	.143	.040	.322	.630	.641
3. Space 3/R	.280	.418	.386	.248	.604	.000	.002	.391	.981	.864
4. Space 4/R	.096	.462	.225	-.038	.341	.274	.027	.110	.479	.477
5. Space 5/R	.314	.525	.309	-.023	.328	.317	.089	.080	.693	.704
6. Space 6/R	.172	.410	.246	.190	.222	.439	-.008	.067	.541	.559
7. Synonyms	.714	.060	.199	.478	-.035	.085	.091	-.018	.799	..826
8. Word Formation	.772	.111	.229	.323	.021	-.007	.148	-.009	.788	.808
9. Verbal Analogies	.506	.149	.377	.408	-.021	.381	.041	.047	.736	.775
10. No. Letter Series	.389	.389	.294	.210	.101	.484	.055	-.017	.681	.713
11. Word Series	.527	.170	.467	.269	.027	.320	.083	.096	.716	.770
12. Non-verb. Intell., Jenkins	.380	.276	.350	.396	.114	.435	.003	.088	.710	.739
13. Mechanical Arithmetic	.638	.110	.361	.001	.005	.004	.191	.027	.587	.589
14. Problem Arithmetic	.715	.231	.405	.080	.040	.154	.191	.011	.797	.825
Sum of squares of loadings.	3.165	1.477	1.545	.917	1.029	1.099	.125	.340	9.700	9.821
Percentage of total variance.	22.61	10.55	11.04	6.55	7.35	7.85	.89	2.43	69.26	70.15

(3) Interpretations.

First let us consider the second-order factors of Table XXVI.

(i) Factor p.

This factor is nearest to tests 7, 8, 13 and 14, all of which are attainment tests. In addition, we notice that the loadings in this factor of the spatial and non-verbal intelligence tests are extremely small. A reasonable assumption would be that the underlying factor is schooling.

According to the table given on page 139, the correlation of this factor with the oblique verbal factor is .517 and with the oblique number factor .708. The factor is approximately orthogonal to the oblique reasoning and spatial factors.

(ii) Factor q.

q-factor loadings are all greater than .28 and the factor accounts for a larger percentage of the common factor variance than any other factor. We find, on consulting the above mentioned table, that it is closest to the oblique reasoning and verbal factors, its correlations with them being .722 and .720 respectively. It seems reasonable to identify the factor as "g".

We will now consider the second-order solution given in Table XXVII.

(i) Factor p.

The tests with the highest loadings in this factor are 7, 8, 13 and 14 and according to the table given on page 145, the correlation of this factor with the oblique verbal factor is .653 and with the oblique number factor .854. We may reasonably infer that the underlying factor is schooling. That there is a close correspondence between this factor and factor p obtained from the boys' data, may be seen from the fact that the correlation between the two p-columns is approximately .93.

(ii) Factors q and r.

The factors represented in columns q and r cannot be identified with confidence and for this reason the girls' solution is rather unsatisfactory as it stands. Even if we retain only two second-order factors, we are unable to rotate them so as to obtain a solution which is as acceptable as the boys' and it was therefore considered desirable to revise the solution.

(4) A Revision of the Girls' Solution.

The plausible nature of the boys' solution in terms of four oblique factors (verbal, space, reasoning and number) with two underlying second-order factors, namely "g" and schooling, occasions us to seek a similar solution for the girls. Such a solution can clearly be found, for we saw at the end of the

last chapter[66] that on rotating the girls' centroid axes to the same relative positions as the boys', the structure we obtained agreed quite closely with the boys' results. All that needs to be done is to post-multiply this structure by the boys' matrix $D^{-1}E$ given on page 140 and the more satisfactory analysis of Table XXVIII is obtained.

66. Supra, p. 137.

TABLE XXVIII REVISED SECOND-ORDER SOLUTION - GIRLS.

Test	Factor Loadings							Communalities	
	p	q	a	b	c	d	e	Obtained	Centroid
1. Space 1/R	.026	.454	.120	.474	.058	-.124	.235	.520	.532
2. Space 2/R	.077	.536	.014	.540	.104	.188	.014	.631	.641
3. Space 3/R	.072	.626	.203	.619	-.045	-.057	.112	.839	.864
4. Space 4/R	-.057	.339	-.112	.495	.236	.038	.252	.496	.477
5. Space 5/R	.116	.459	-.087	.520	.297	.127	.343	.724	.704
6. Space 6/R	.002	.508	-.030	.331	.383	-.011	.212	.560	.559
7. Synonyms	.560	.566	.363	-.128	.115	.027	.147	.818	.826
8. Word Formation	.613	.503	.316	-.020	.047	.118	.210	.789	.808
9. Verbal Analogies	.349	.673	.170	.024	.357	.123	.058	.750	.775
10. No. Letter Series	.202	.572	.005	.233	.455	.094	.270	.711	.713
11. Word Series	.373	.646	.114	.136	.309	.240	.050	.744	.770
12. Non-verb. Intell., Jenkins	.200	.687	.125	.167	.387	.033	.110	.718	.739
13. Mechanical Arithmetic	.525	.358	.094	.125	.062	.348	.140	.573	.589
14. Problem Arithmetic	.549	.510	.096	.182	.199	.330	.230	.805	.825
Sum of Squares of loadings	1.637	4.100	0.384	1.691	0.945	0.399	.523	9.678	9.821
Percentage of total variance	11.69	29.29	2.74	12.08	6.75	2.85	3.74	69.13	70.15

The agreement between this solution and the boys' given in Table XXVI is remarkably good and the factors represented in corresponding columns bear the same interpretation.

We observe that each of the factors "g" and schooling accounts for a larger percentage of the total test variance for girls than for boys and this is in accordance with the finding reported in Chapter VI, that the mean inter-test correlation for girls was significantly larger than for boys. Only one other point of difference attracts our attention, namely, that factor d (the orthogonal number factor) is less marked for girls and this is consistent with the fact that the fourth centroid factor for girls was not as greatly significant as the corresponding factor for boys.

The apparent lack of uniqueness of the factor solutions is somewhat disquieting, but the "simple structures" presented on page 137 and the second-order analyses of Tables XXVI and XXVIII do provide a plausible explanation of the factors involved in the tests and they will therefore be accepted as final for our investigation. It is probable that the lack of uniqueness is due to the fact that there were too few tests in our battery for a complete determination of the "simple structure".

By averaging the squares of corresponding entries in Tables XXVI and XXVIII we obtain an approximate,

though convenient, estimation of the extent to which each factor enters into the different tests.

Test	Factors (Percentage of).					
	"g"	schooling	"v"	"s"	"r"	"n"
Space 1/R	14	-	-	26	-	-
Space 2/R	24	-	-	25	-	-
Space 3/R	29	-	-	44	-	-
Space 4/R	17	-	-	20	5	-
Space 5/R	23	-	-	28	6	-
Space 6/R	30	-	-	9	16	-
Synonyms	37	28	15	-	-	-
Word Formation	30	34	11	-	-	-
Verbal Analogies	40	11	3	-	13	-
No. & Letter Series	34	-	-	5	23	-
Word Series	36	13	2	-	10	-
Non-verb.Intell.,Jenkins.	42	-	-	6	14	-
Mech. Arith.	12	25	-	-	3	18
Problem Arith.	26	28	-	-	7	15

It will be remembered that the six factors represented above are orthogonal. We use small letters to distinguish the verbal, space, reasoning and number components from their respective oblique factors.

CHAPTER IX.

SUMMARY AND CONCLUSIONS.

(1) Summary.

Purpose of the Study.

The purpose of the study was to investigate the nature and existence of specialized factors of intelligence measurable at the transfer stage (age eleven), with especial reference to the factors underlying both two and three dimensional space tests. The study has an important bearing on the problem of selecting children for different kinds of secondary education.

The Test Battery.

With one exception, all the tests were specially constructed for the experiment from tests which had been previously subjected to a detailed item-analysis. As a consequence, the tests gave good discrimination and proved highly reliable. In addition to both two and three dimensional space tests, the battery contained verbal and non-verbal intelligence tests and attainment tests in English and Arithmetic. The average number of items per test was 80 and the average time allowance 35 minutes.

The Experimental Group.

The tests were administered to a representative sample of eleven-year old children from 14

different schools in the city of Edinburgh. Only those children who sat all tests were included in the experimental group, which consisted of 206 boys and 229 girls. The sexes were parallel with respect to age and both educational and social background.

Sex Differences in Test Performance.

It was found that:-

(i) The boys were highly superior to the girls in all the space tests and also in the problem arithmetic test. For the other tests the differences were not significant. The mean "intelligence quotient" for the girls as measured by Jenkins' Test was higher than for the boys, though not significantly so.

(ii) Except for the mechanical arithmetic test, boys' standard deviations of raw scores were all higher than those for the girls.

The Factorial Analysis.

The Matrices of intercorrelations, from which age had been partialled out, were analysed separately for boys and girls by Thurstone's Centroid Method. Five factors were extracted for boys and the same number for girls. These were rotated to "simple structure" by the method of extended vectors and second-order analyses completed. Careful consideration was given to various problems relating to the Centroid Method of analysis, including that of estimating communalities and the question of how many factors to extract. In addition, a study was made of

the influence which errors in communality estimation have on the accuracy of factor loadings.

A plausible solution was obtained for the boys in terms of four oblique factors (verbal, space, reasoning and number) with two underlying second-order factors, namely "g" and schooling. The initial rotation to "simple structure" for the girls' data gave a solution which was psychologically unsatisfactory in that it yielded three second-order factors, two of which could not be interpreted with confidence. On rotating the girls' centroid axes to the same relative positions as the boys', the "simple structure" and also the second-order analysis agreed quite closely with the boys' results. Lack of uniqueness of the factor solutions is somewhat disquieting but they do provide a plausible explanation of the factors involved in the tests. The "simple structures" are presented on page 137 and the second-order analyses in Tables XXVI and XXVIII.

(2) Conclusions.

As a result of our investigation we are able to draw the following conclusions:-

(i) The general factor of intelligence is the most important single factor influencing the test performances of eleven-year olds, but the contribution of specialized factors at this age is by no means inappreciable. In particular, the space factor - the

existence of which has been disputed - is clearly in evidence.

(ii) The space factor is involved in both the two and three dimensional tests.

(iii) There is a slight indication, based on averaging the loadings, that the two dimensional tests are more closely linked with the space factor than the three dimensional tests. What is perhaps more suggestive, however, is the fact that the tests with the highest loadings in the factor are those in which the subject has to visualize the form of an object when it is moved to an alternative position, irrespective of whether the object is two or three dimensional in character.

(iv) It is a reasoning and not a visual factor which distinguishes the two and three dimensional space tests of our battery and this finding provides a likely explanation of the common element underlying the three dimensional half of Moray House Space Test 1 and Raven's Matrices previously reported.

(v) At least one of the new space tests, namely 3/R, may be considered to be very satisfactory in that it is highly loaded with both "g" and the space factor.

(vi) Particular interest centres in the nature of the factorial solution we have found; it is through such a solution that a reconciliation between the various conflicting theories of intelligence might be obtained.

(vii) Finally, it is suggested that the present study should be supplemented by a follow-up inquiry into the predictive value of the various tests for different types of secondary school courses.

APPENDICES TO THE THESIS

A FACTORIAL STUDY

OF

TWO AND THREE DIMENSIONAL SPACE TESTS

by

Thomas Renshaw, B.Sc., B.Ed.

MAY 15th 1950.

TABLE OF CONTENTS:

APPENDIX I

The Tests used in the Experiment.

DO NOT TURN OVER OR OPEN THIS BOOK UNTIL YOU ARE TOLD.

MORAY HOUSE EXPERIMENTAL

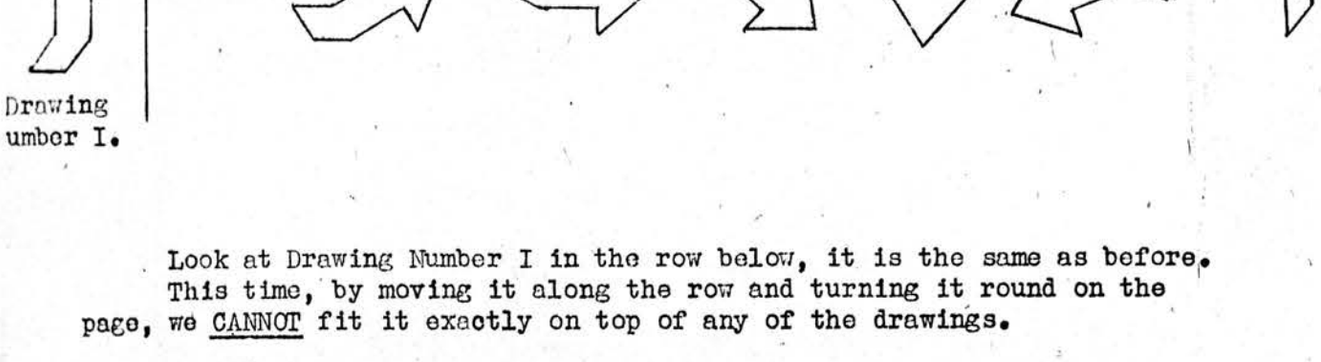
S P A C E T E S T I/R

Not to be filled in by the Scholar	
Age in years and completed months y. m.	
Page	Score
3.	
4.	
5.	
6.	
7.	
8.	
TOTAL	
Signature of Marker:	

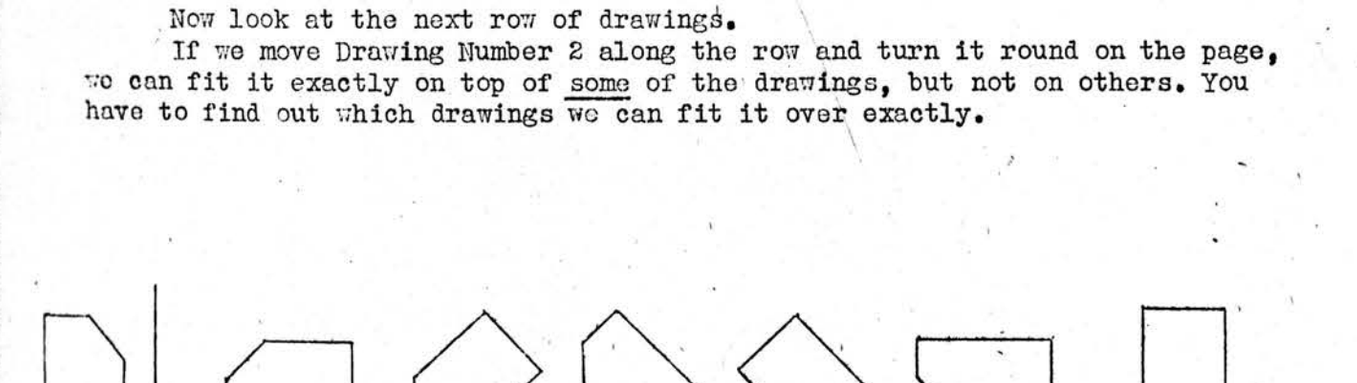
Fill in the following particulars at once:-

1. Your Surname (In capital letters).....
2. Your Christian Name(s) (In capital letters).....
3. Sex (Boy or Girl).....
4. Name of Your School.....
5. Class You are in.....
6. Your age.....years
7. Date of Your Birthday.....
8. Today's Date.....

Look at Drawing Number I in the row below.
Suppose we move it along the row and turn it round on the page. We can fit it exactly on top of each drawing, in turn.



Look at Drawing Number I in the row below, it is the same as before.
This time, by moving it along the row and turning it round on the page, we CANNOT fit it exactly on top of any of the drawings.



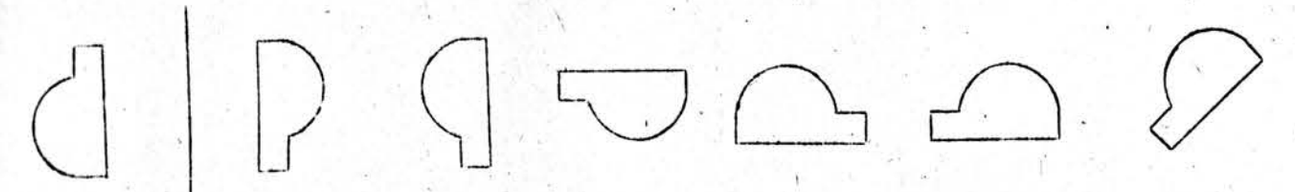
Now look at the next row of drawings.
If we move Drawing Number 2 along the row and turn it round on the page, we can fit it exactly on top of some of the drawings, but not on others. You have to find out which drawings we can fit it over exactly.

(a) ✓ (b) ✓ (c) ____ (d) ✓ (e) ____ (f) ✓

We can fit Drawing Number 2 exactly on top of Drawings (a), (b), (d), and (f). So we have placed a tick (✓) on the line under each of them.

GO STRAIGHT ON TO PAGE 2.

In the row of drawings below, **place** a tick (✓) under <u>each</u> drawing which Drawing Number 3 will fit when turned round on the page. Do <u>not</u> place a tick under those drawings which Drawing Number 3 does <u>not</u> fit.

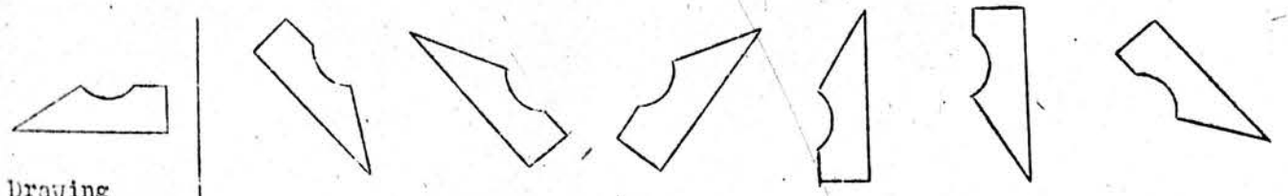


Drawing Number 3

(a) ____ (b) ____ (c) ____ (d) ____ (e) ____ (f) ____

You should have placed a tick under drawings (a), (c), and (d).

Now do the next row in the same way.



Drawing Number 4

(a) ____ (b) ____ (c) ____ (d) ____ (e) ____ (f) ____

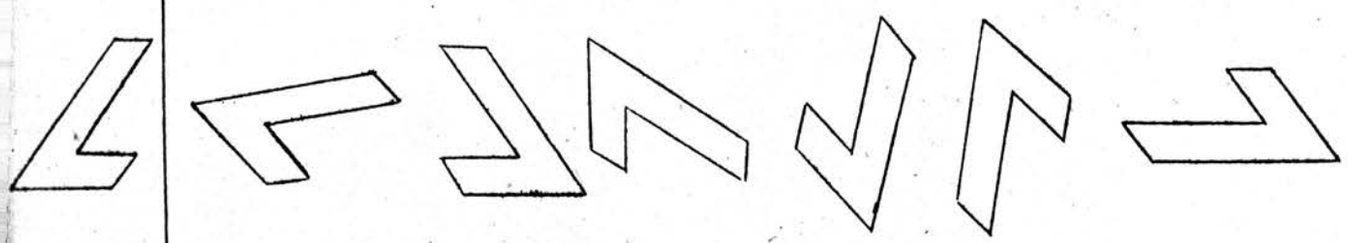
You should have placed a tick under drawings (b), (e), and (f).

<u>Now read the following carefully.</u>

1. All the questions in this test are like those you have just done.
2. When you are told to begin, turn to page 3 and start working at once.
3. Work as quickly and as carefully as you can.
4. Make any alterations in your answers clearly.
5. You will have 45 minutes and you will be told the time every quarter of an hour. No one is expected to do everything. Just do as much as you can.

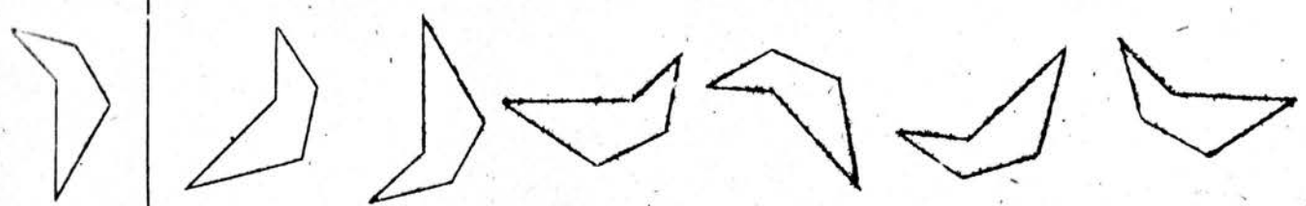
<u>DO NOT TURN OVER UNTIL YOU ARE TOLD.</u>

Now do these questions in the same way. Place a tick under <u>each</u> drawing which is the same as the drawing on the left when turned round on the page. There is more than one answer to each question.



1.

(a) _____ (b) _____ (c) _____ (d) _____ (e) _____ (f) _____



2.

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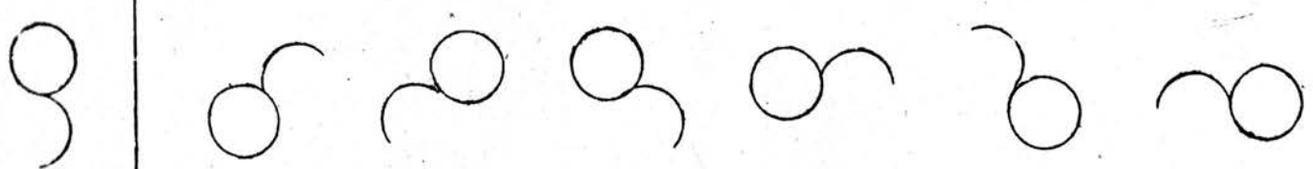
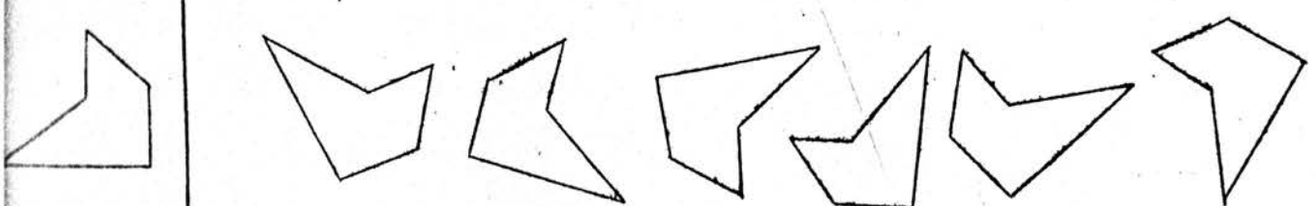


3.

(a) _____ (b) _____ (c) _____ (d) _____ (e) _____ (f) _____



4.

(a) _____ (b) _____ (c) _____ (d) _____ (e) _____ (f) _____

5.

(a) _____ (b) _____ (c) _____ (d) _____ (e) _____ (f) _____

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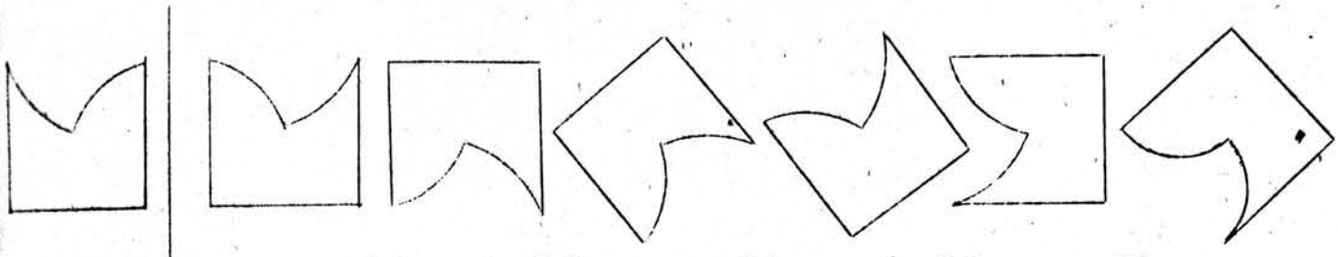
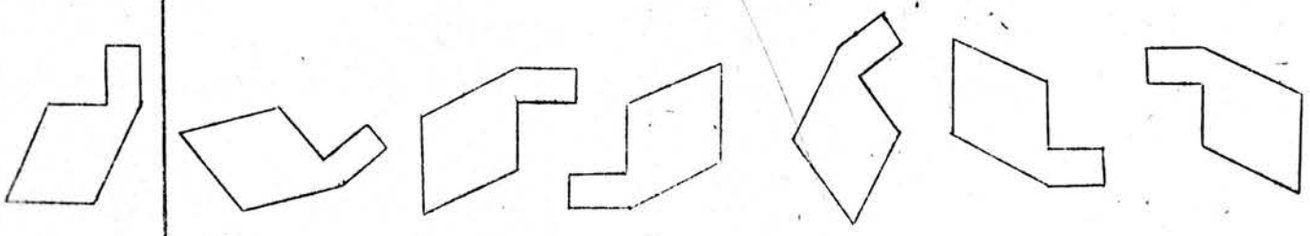


6. (a) _____ (b) _____ (c) _____ (d) _____ (e) _____ (f) _____

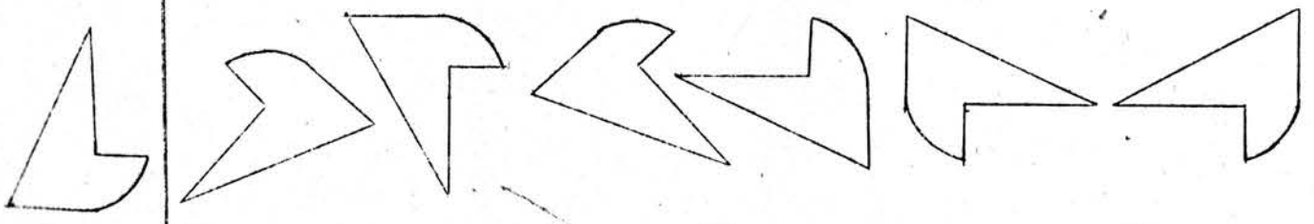
7. (a) _____ (b) _____ (c) _____ (d) _____ (e) _____ (f) _____

8. (a) _____ (b) _____ (c) _____ (d) _____ (e) _____ (f) _____

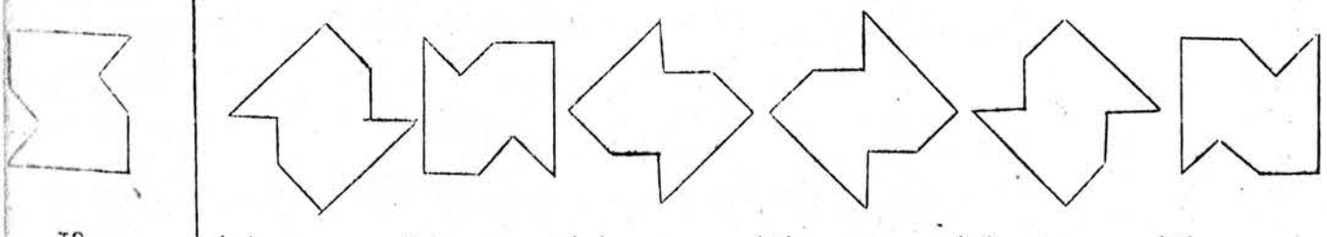
9. (a) _____ (b) _____ (c) _____ (d) _____ (e) _____ (f) _____



10. (a) _____ (b) _____ (c) _____ (d) _____ (e) _____ (f) _____



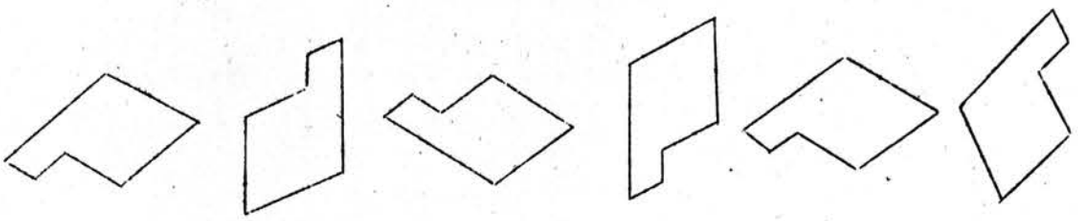
11. (a) _____ (b) _____ (c) _____ (d) _____ (e) _____ (f) _____



12. (a) _____ (b) _____ (c) _____ (d) _____ (e) _____ (f) _____

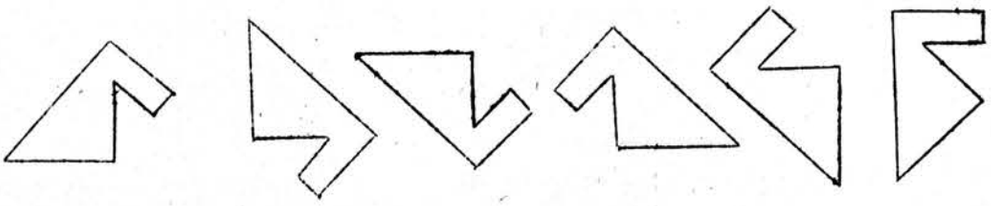
GO STRAIGHT ON TO PAGE 5.

I3.



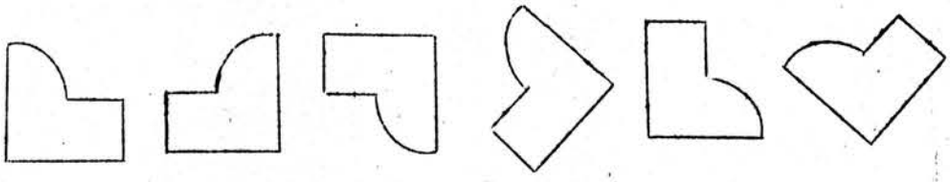
(a) _____ (b) _____ (c) _____ (d) _____ (e) _____ (f) _____

I4.

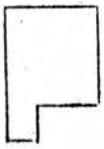


(a) _____ (b) _____ (c) _____ (d) _____ (e) _____ (f) _____

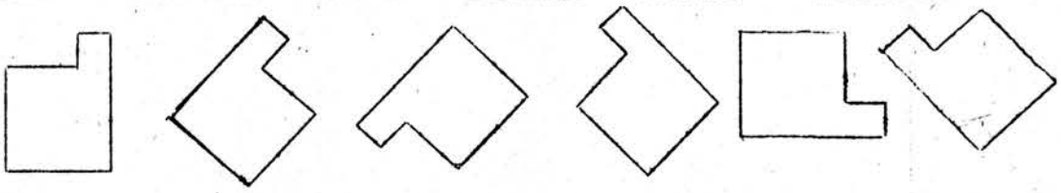
I5.



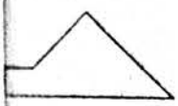
(a) _____ (b) _____ (c) _____ (d) _____ (e) _____ (f) _____



I6.



(a) _____ (b) _____ (c) _____ (d) _____ (e) _____ (f) _____



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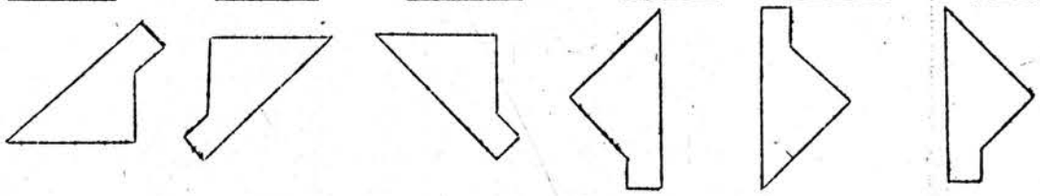

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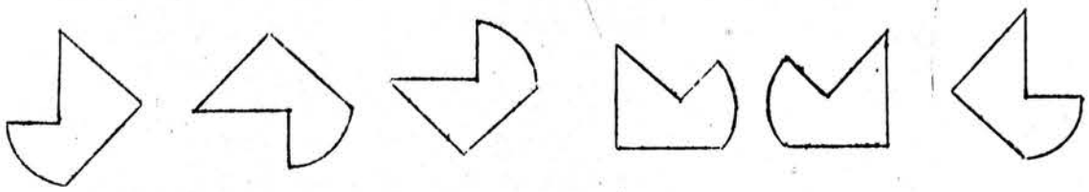
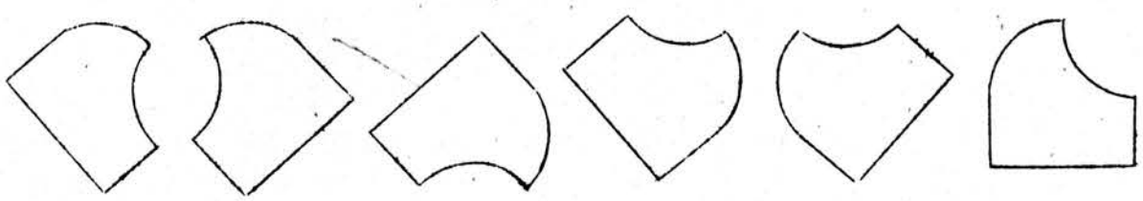
I8.



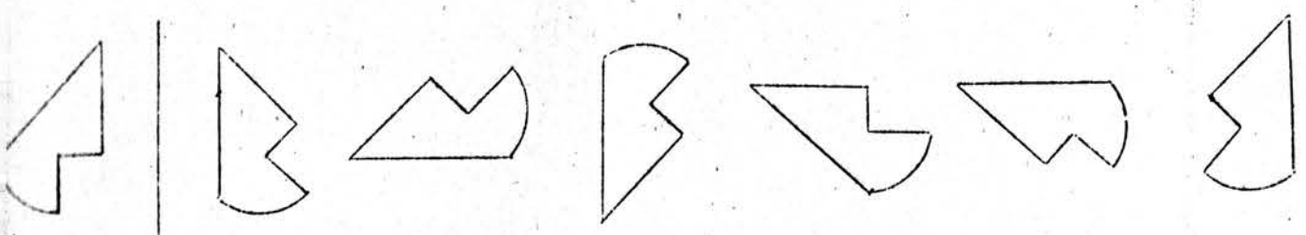
(a) _____ (b) _____ (c) _____ (d) _____ (e) _____ (f) _____

I9.

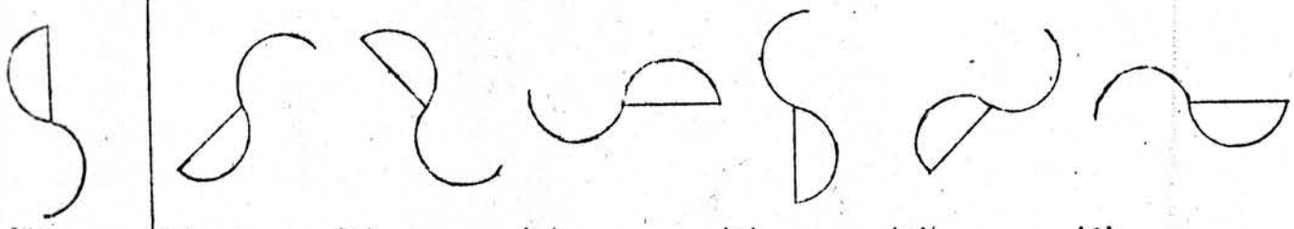


(a) _____ (b) _____ (c) _____ (d) _____ (e) _____ (f) _____

GO STRAIGHT ON TO PAGE 6.

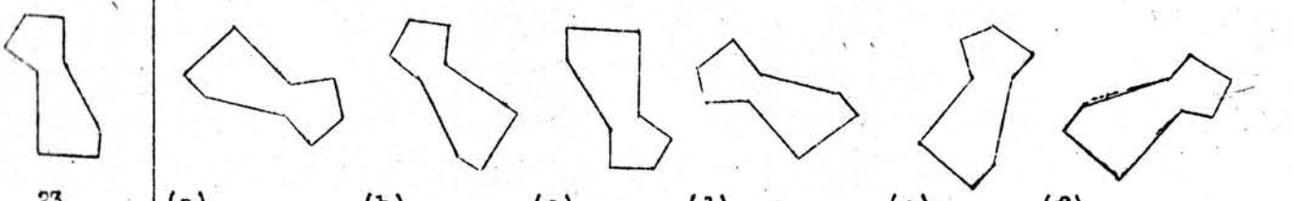


20. (a) _____ (b) _____ (c) _____ (d) _____ (e) _____ (f) _____



21. (a) _____ (b) _____ (c) _____ (d) _____ (e) _____ (f) _____

22. (a) _____ (b) _____ (c) _____ (d) _____ (e) _____ (f) _____



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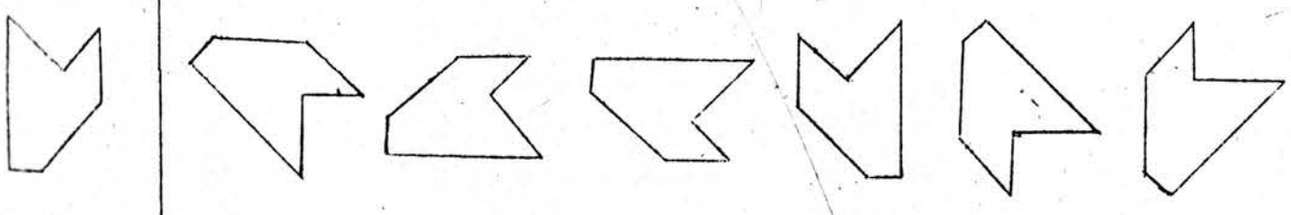
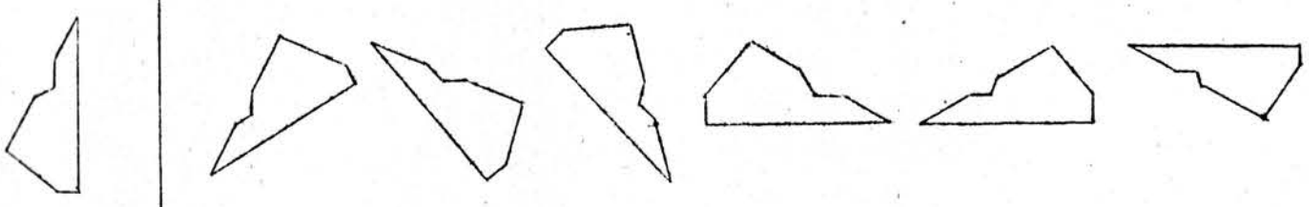
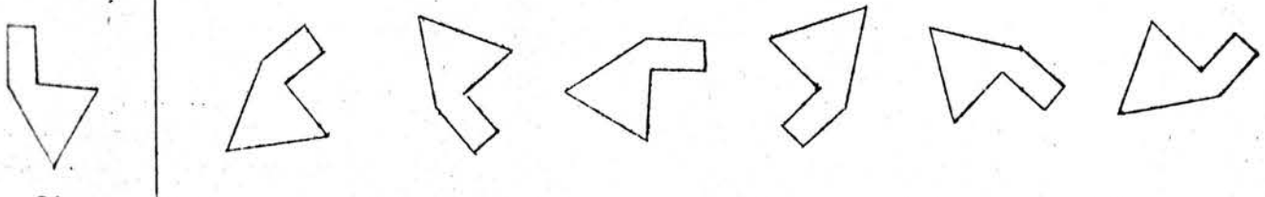


24. (a) _____ (b) _____ (c) _____ (d) _____ (e) _____ (f) _____



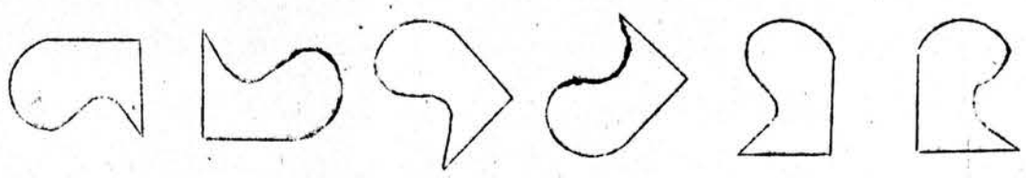
25. (a) _____ (b) _____ (c) _____ (d) _____ (e) _____ (f) _____



26. (a) _____ (b) _____ (c) _____ (d) _____ (e) _____ (f) _____

GO STRAIGHT ON TO PAGE 7.

27.



(a) _____ (b) _____ (c) _____ (d) _____ (e) _____ (f) _____

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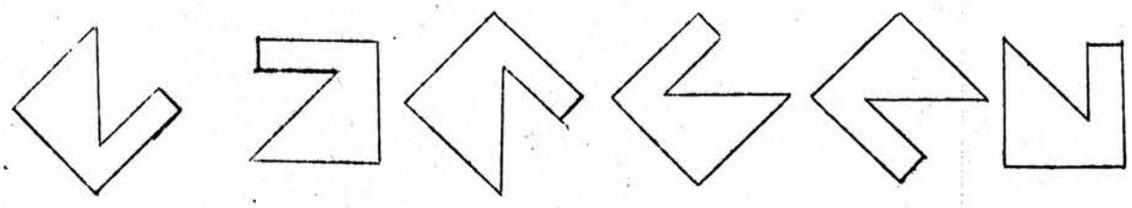

(a) _____ (b) _____ (c) _____ (d) _____ (e) _____ (f) _____

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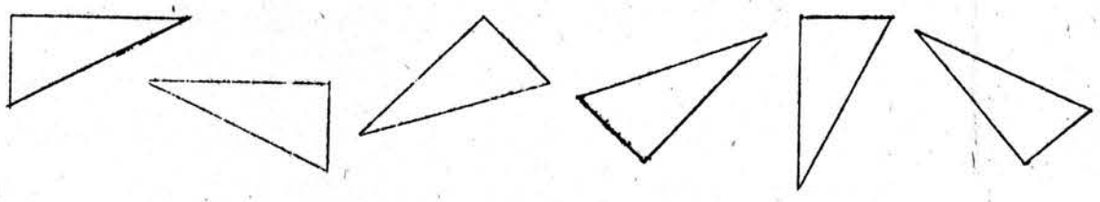
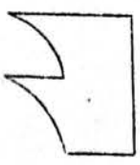


(a) _____ (b) _____ (c) _____ (d) _____ (e) _____ (f) _____



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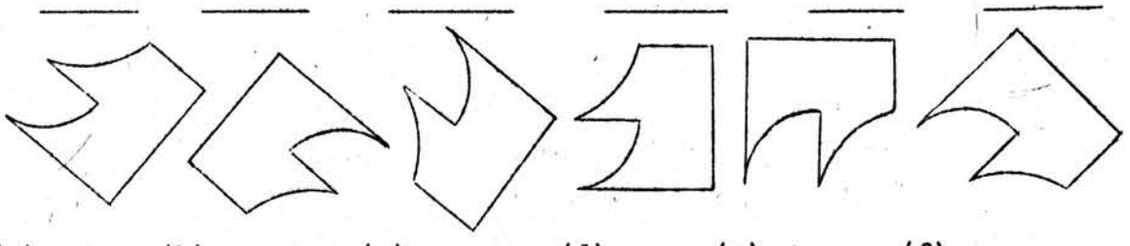
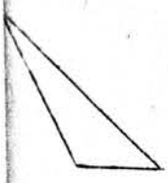


(a) _____ (b) _____ (c) _____ (d) _____ (e) _____ (f) _____



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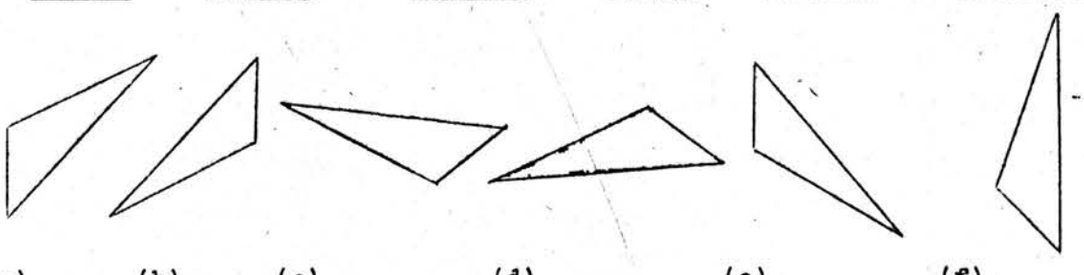
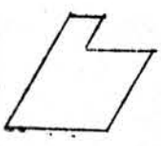


(a) _____ (b) _____ (c) _____ (d) _____ (e) _____ (f) _____



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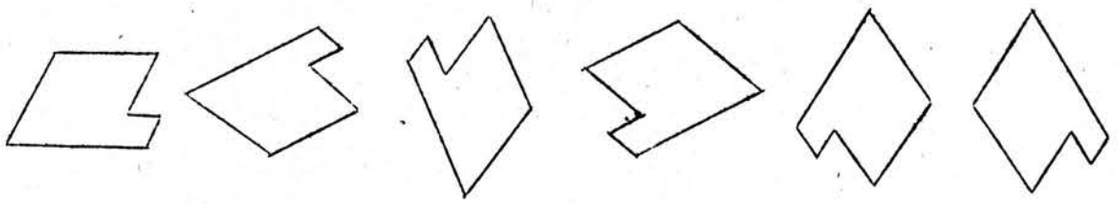
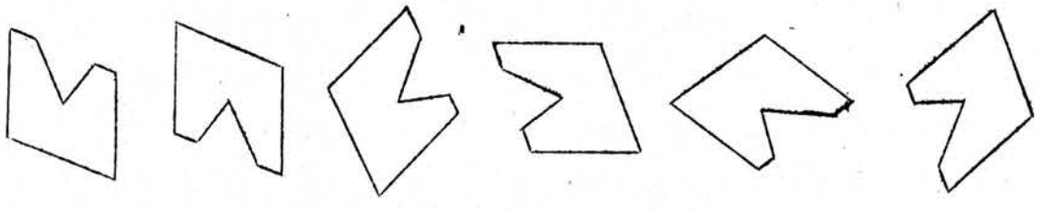


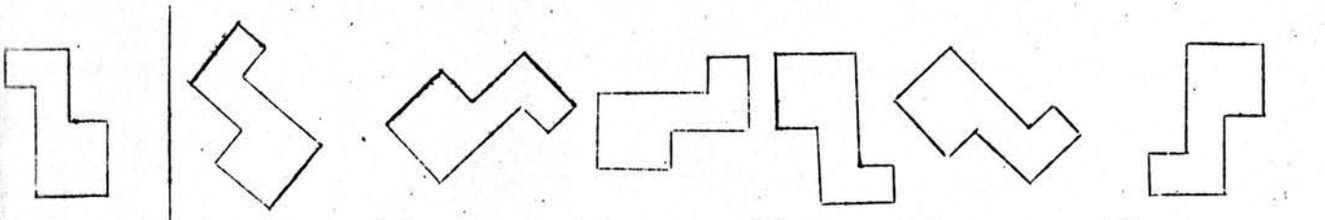
(a) _____ (b) _____ (c) _____ (d) _____ (e) _____ (f) _____

33.

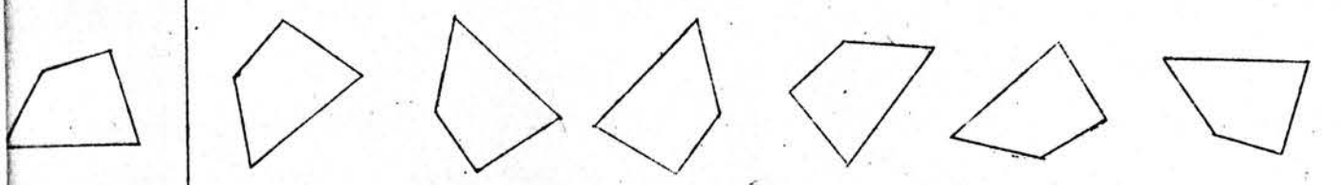


(a) _____ (b) _____ (c) _____ (d) _____ (e) _____ (f) _____

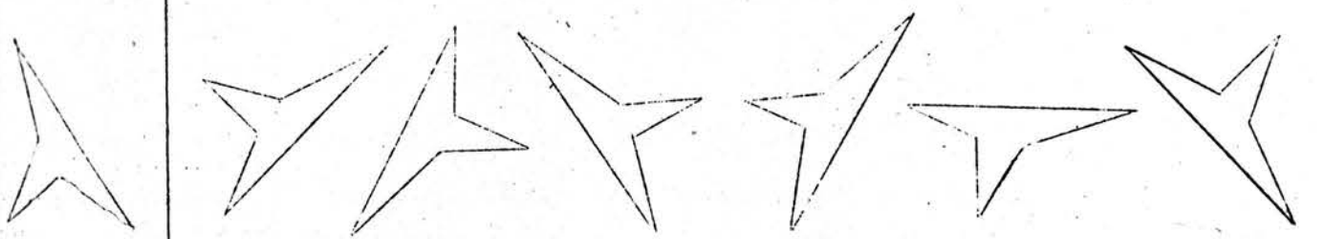
GO STRAIGHT ON TO PAGE 8.



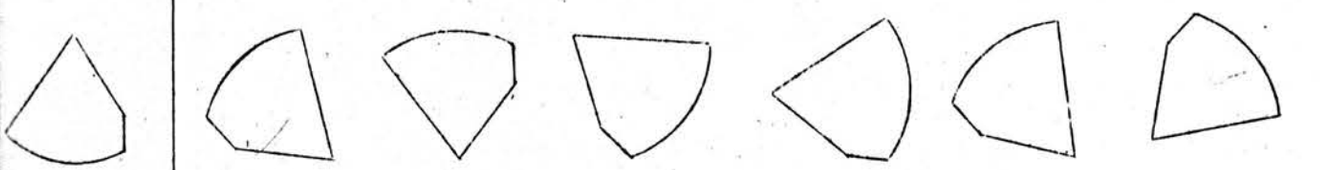
34. (a) _____ (b) _____ (c) _____ (d) _____ (e) _____ (f) _____



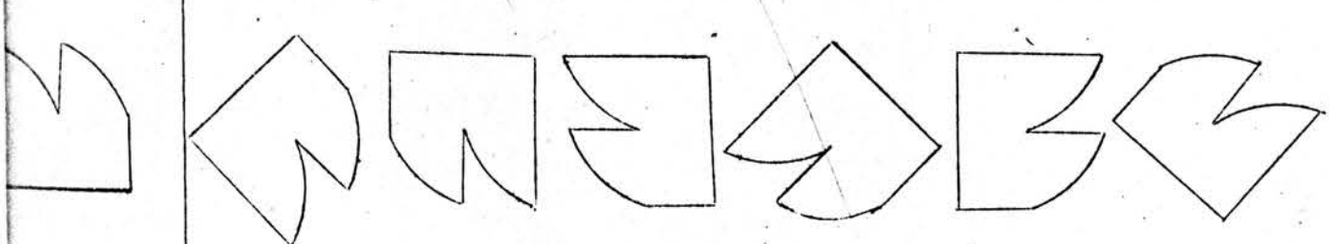
35. (a) _____ (b) _____ (c) _____ (d) _____ (e) _____ (f) _____



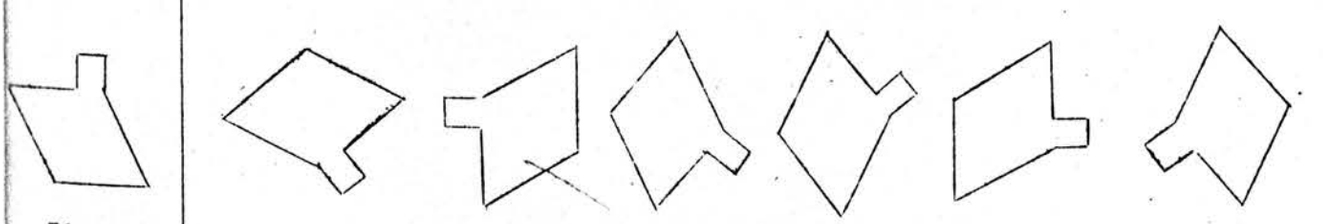
36. (a) _____ (b) _____ (c) _____ (d) _____ (e) _____ (f) _____



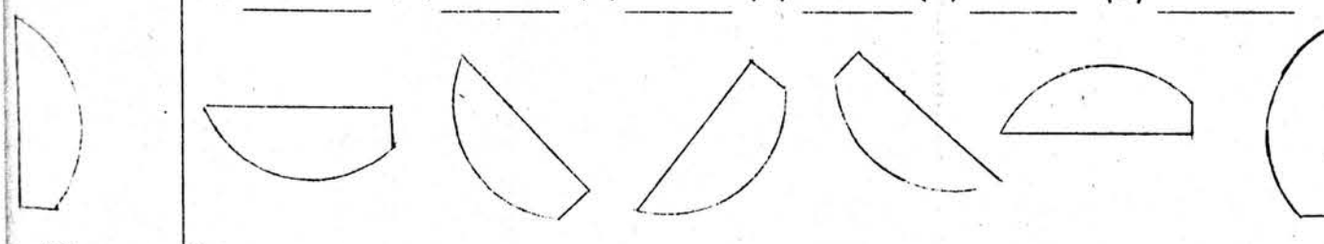
37. (a) _____ (b) _____ (c) _____ (d) _____ (e) _____ (f) _____



38. (a) _____ (b) _____ (c) _____ (d) _____ (e) _____ (f) _____



39. (a) _____ (b) _____ (c) _____ (d) _____ (e) _____ (f) _____



40. (a) _____ (b) _____ (c) _____ (d) _____ (e) _____ (f) _____

LOOK OVER YOUR WORK UNTIL TIME IS UP.

DO NOT TURN OVER OR OPEN THIS BOOK UNTIL YOU ARE TOLD.

M O R A Y H O U S E E X P E R I M E N T A L

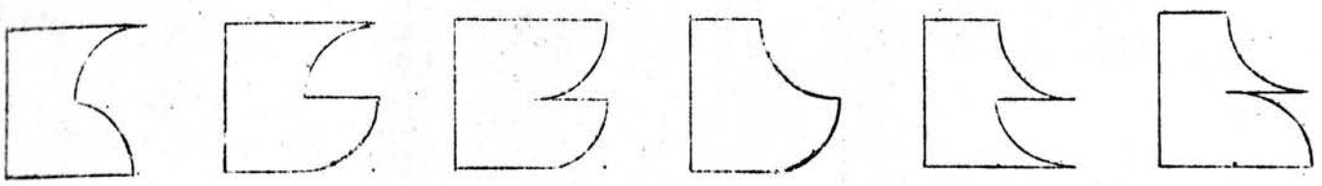
S P A C E T E S T 2/R.

Not to be filled in by the Scholar	
Age in years and completed months. y. m.	
Page	Score
2	
3	
4	
5	
TOTAL	
Signature of marker.	

Fill in the following particulars at once:-

1. Your Surname (In capital letters).....
2. Your Christian Name(s) (In capital letters).....
3. Sex (Boy or Girl).....
4. Name of your school.....
5. Class you are in.....
6. Your Age.....years.
7. Date of Your Birthday.....
8. Today's Date.....

In the row below there are six different shapes, lettered A, B, C, D, E and F.

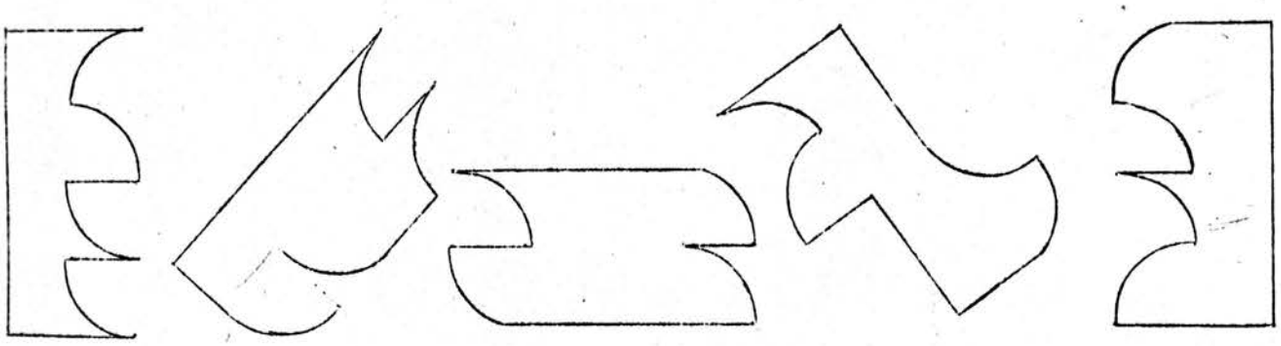


A B C D E F

In the next row, there are some drawings which have been made by fitting together two of the shapes A, B, C, D, E and F.

You have to find out which two shapes have been fitted together in each drawing, and write their letters on the line underneath.

The first question has been done for you. See if you can do the others.



(I) A, E (2) (3) (4) (5)

Notice that some of the shapes have been turned over.

Now check your answers. You should have placed two letters under each drawing.

The answers are:- (I) A, E. (2) C, E. (3) B, C. (4) A, D. (5) A, D.

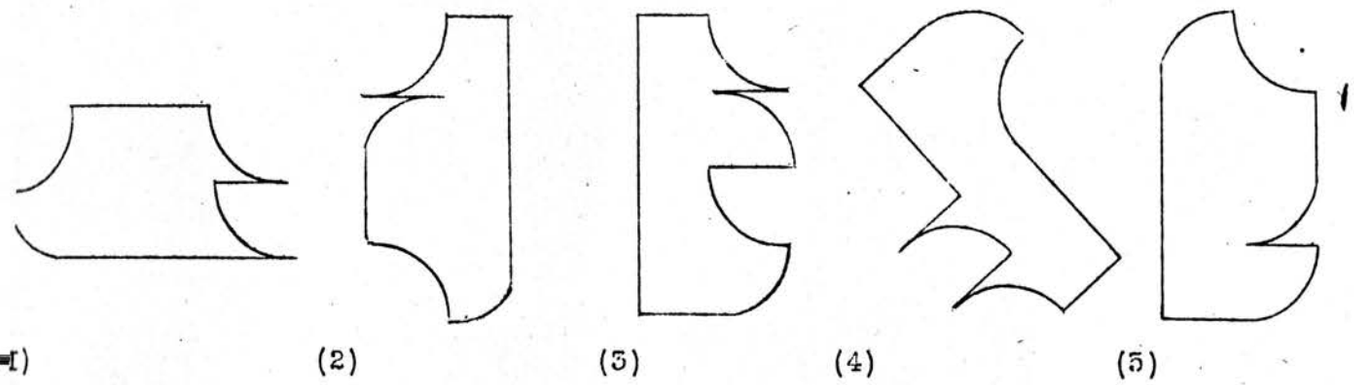
The order of the letters does not matter.

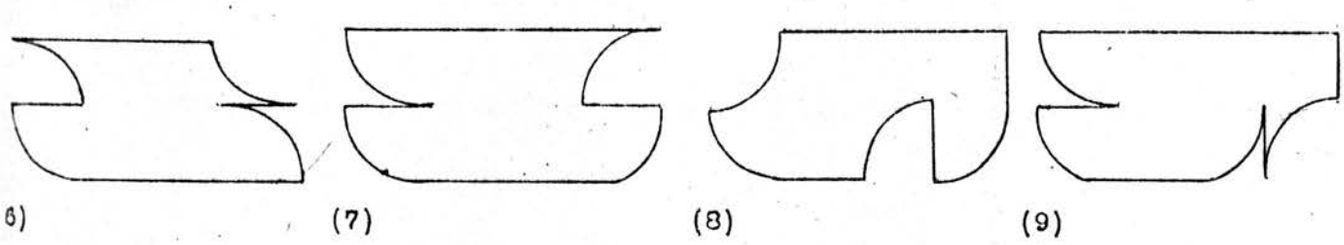
Now read the following carefully:-

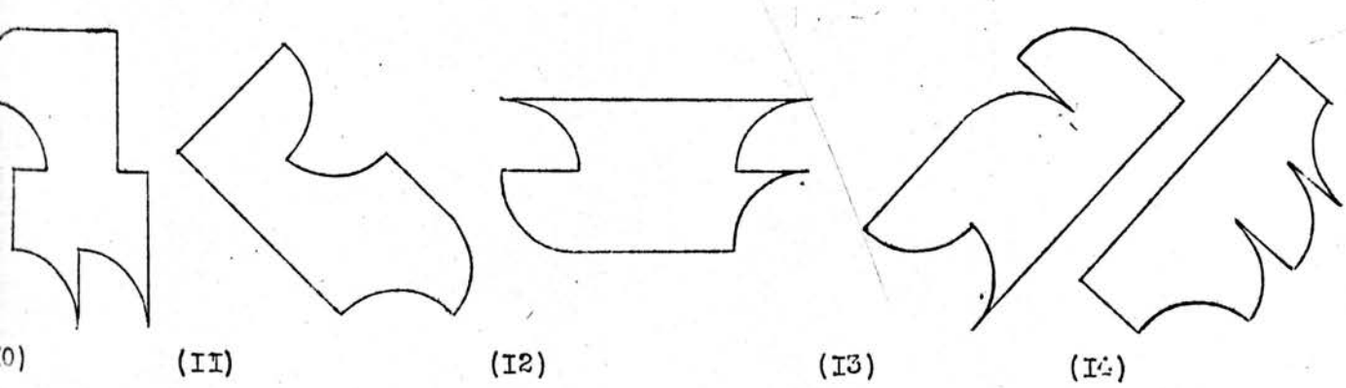
1. All the questions that follow are like those you have just done.
2. When you are told to begin, turn to page 2 and start working at once.
3. Work as quickly and as carefully as you can.
4. Make any alterations in your answers clearly.
5. You will have 40 minutes and you will be told the time every quarter of an hour. No one is expected to do everything. Just do as much as you can.

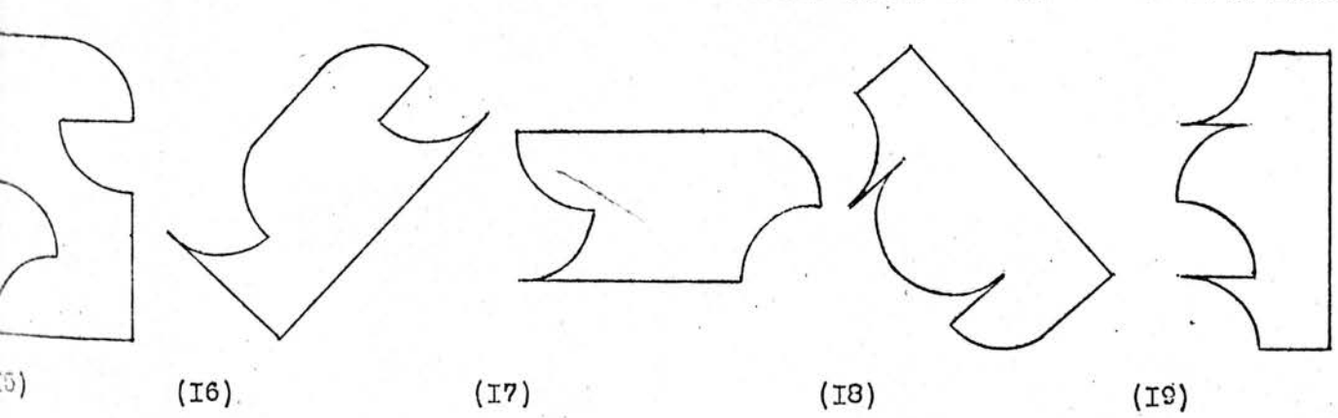
DO NOT TURN OVER UNTIL YOU ARE TOLD.

Do the questions below in the same way as those you have just done. In each drawing, find out which <u>two</u> shapes have been fitted together and write their letters on the line underneath.

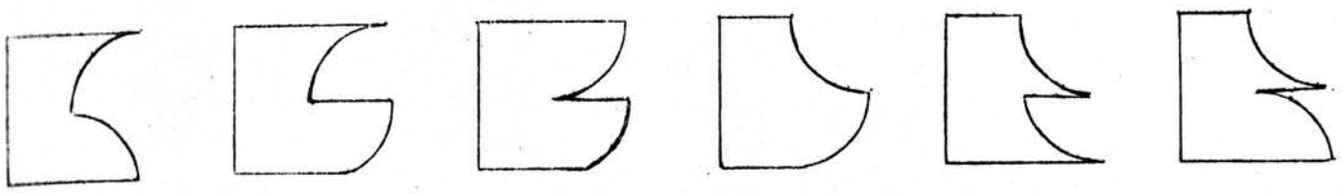




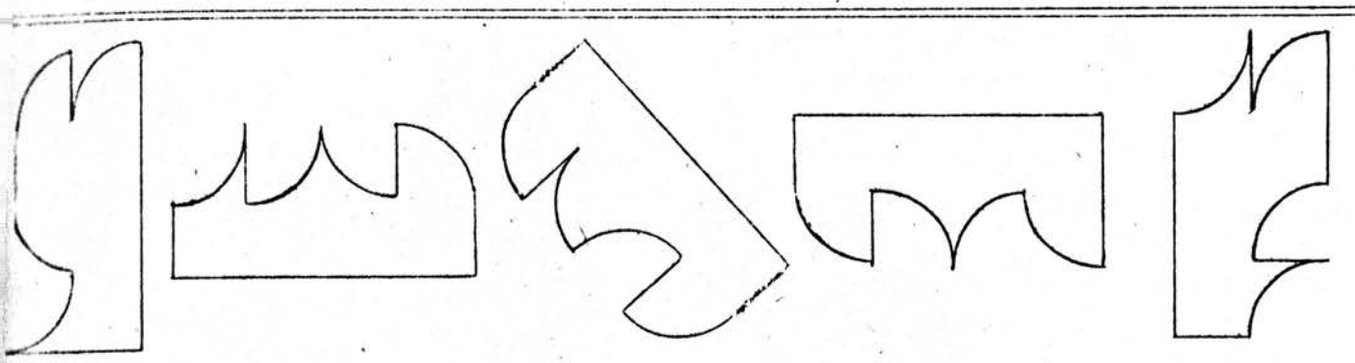




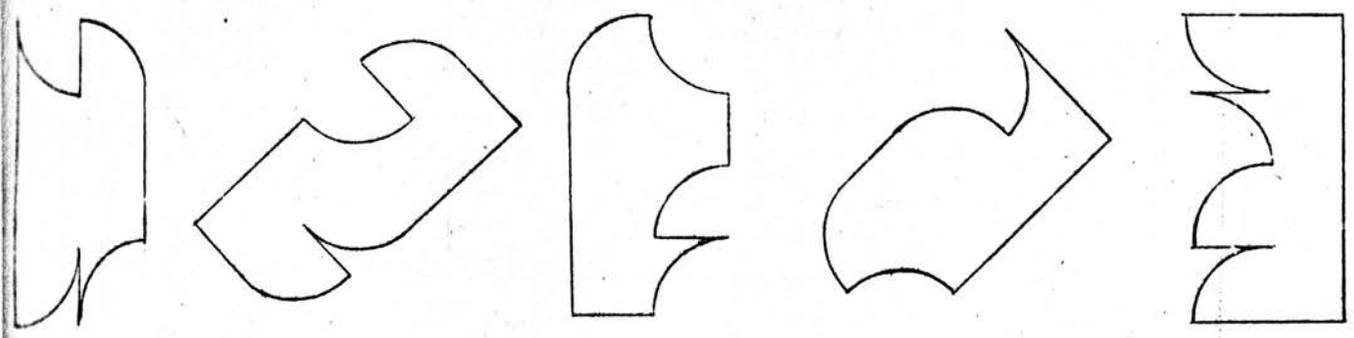
GO STRAIGHT ON TO PAGE 3



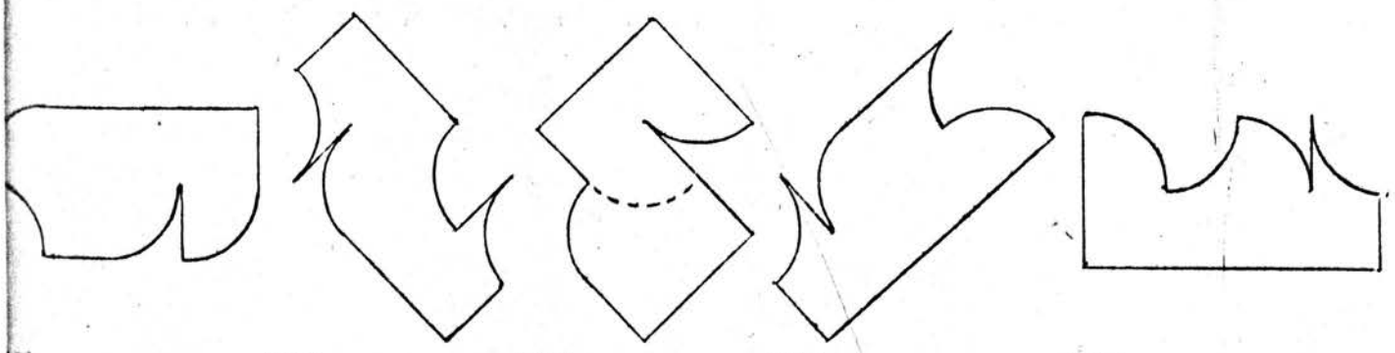
A B C D E F



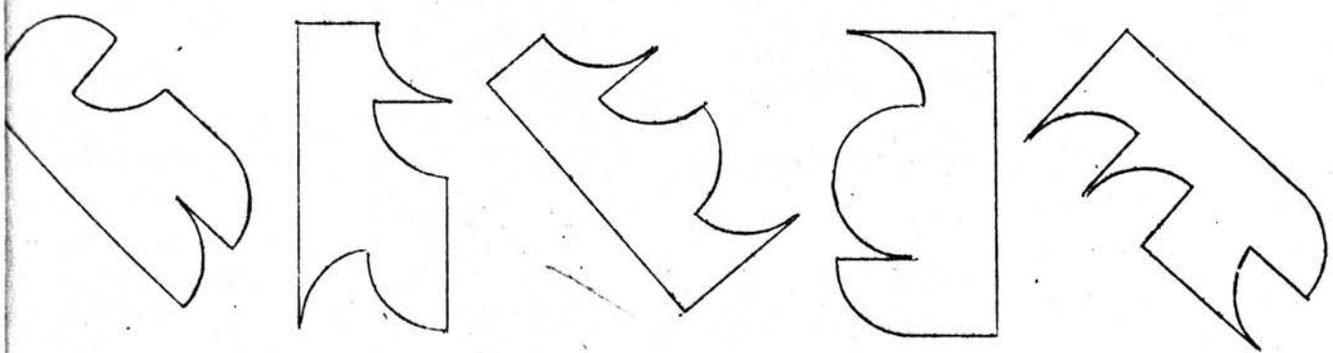
20) (2I) (22) (23) (24)



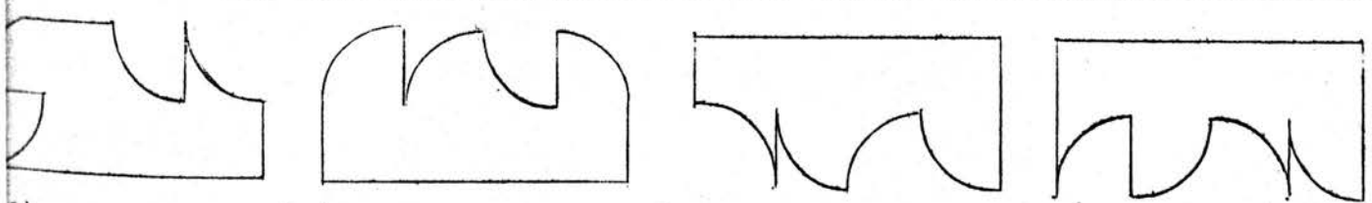
25) (26) (27) (28) (29)



30) (3I) (32) (33) (34)

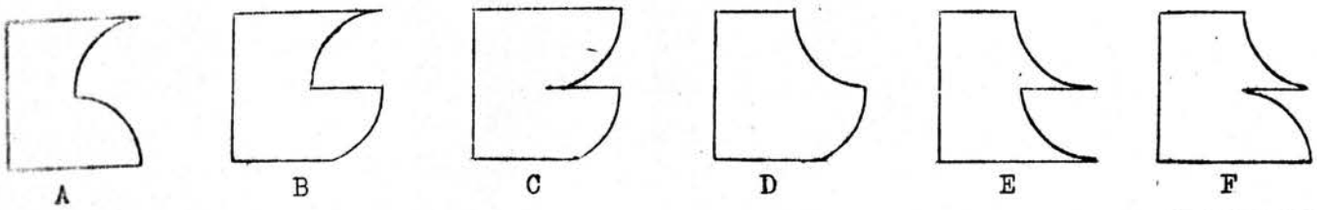


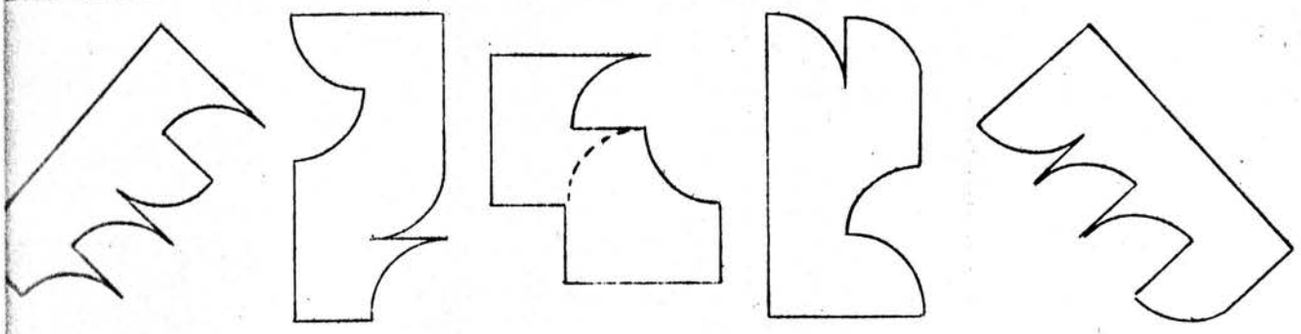
35) (36) (37) (38) (39)

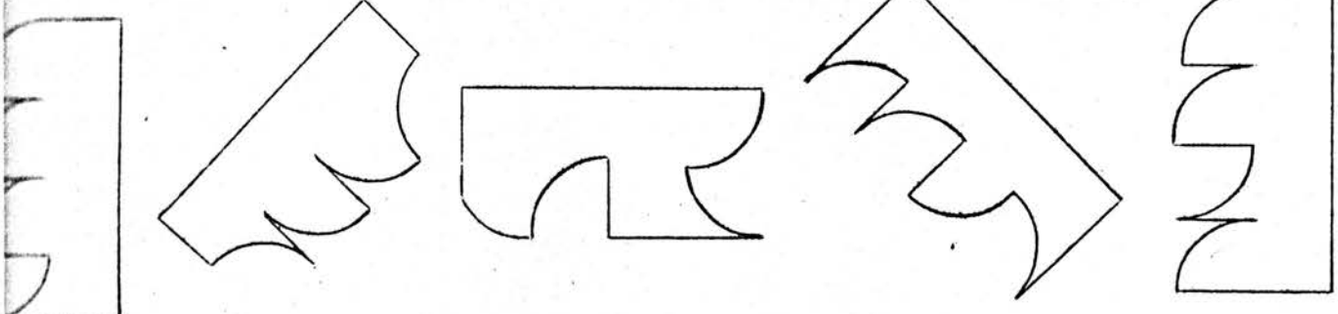


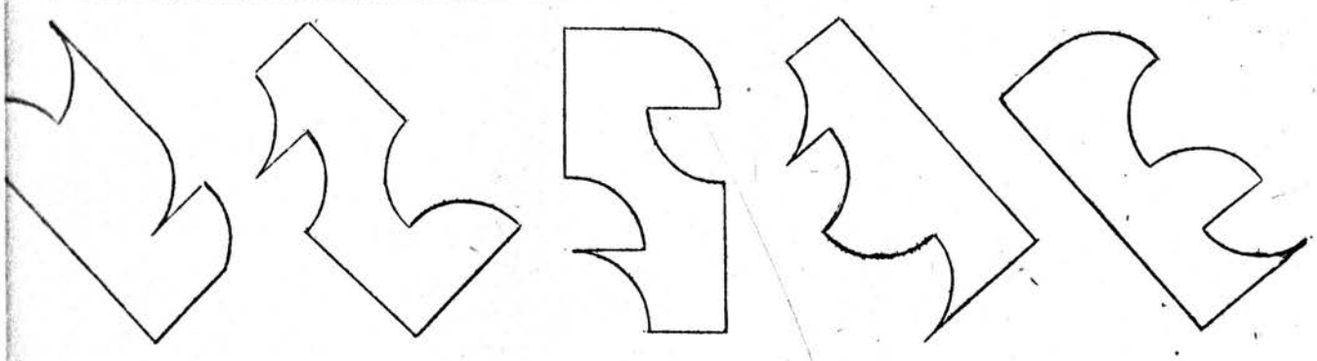
40) (4I) (42) (43)

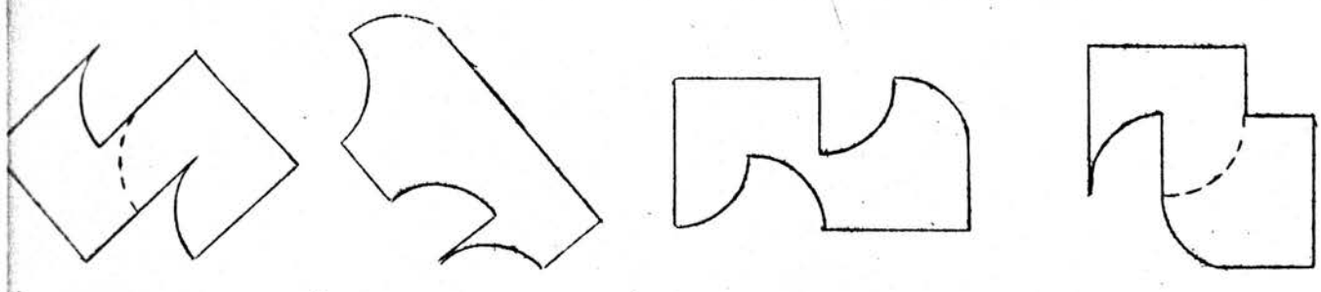
GO STRAIGHT ON TO PAGE 4.

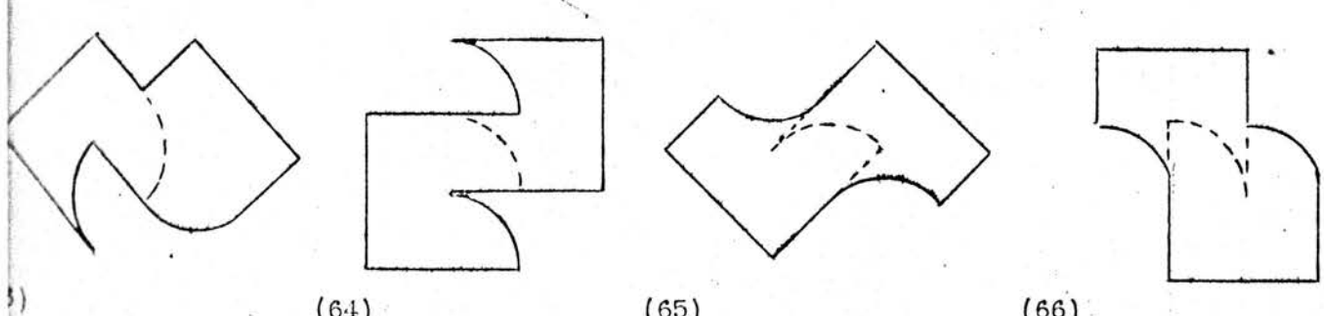




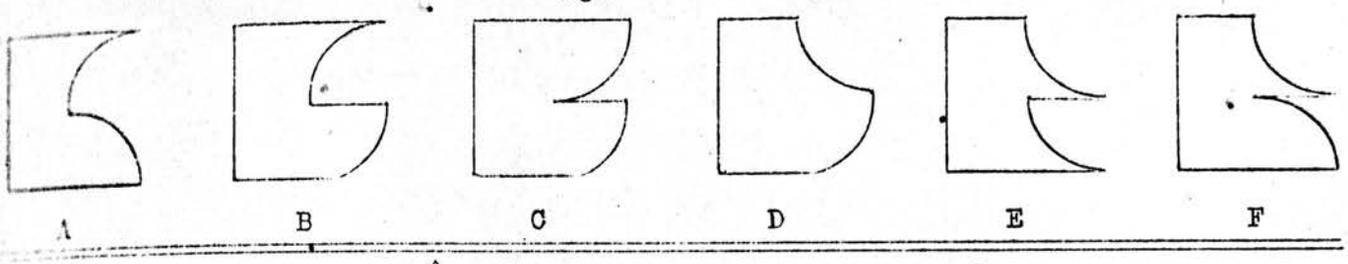


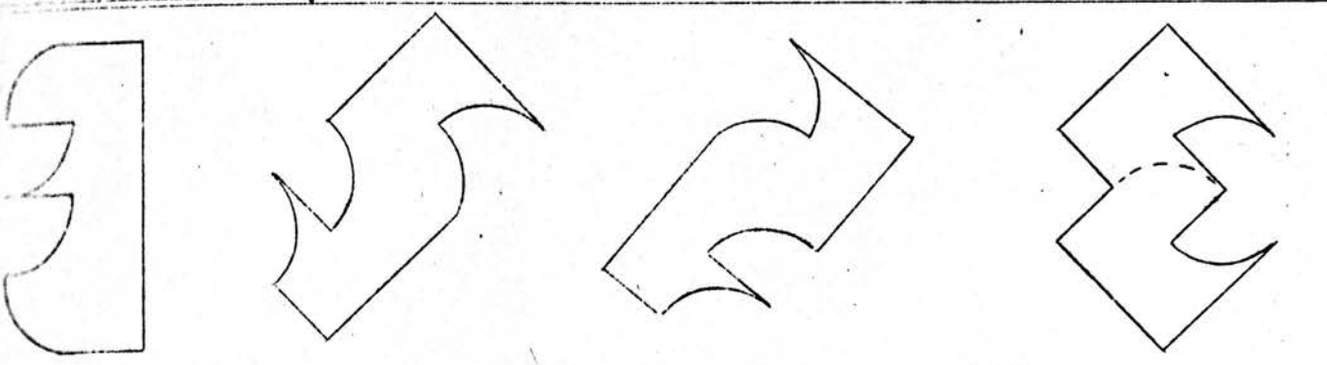


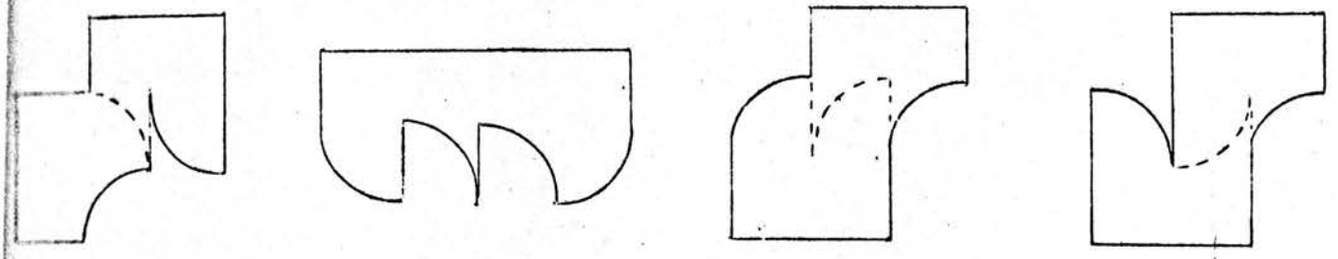


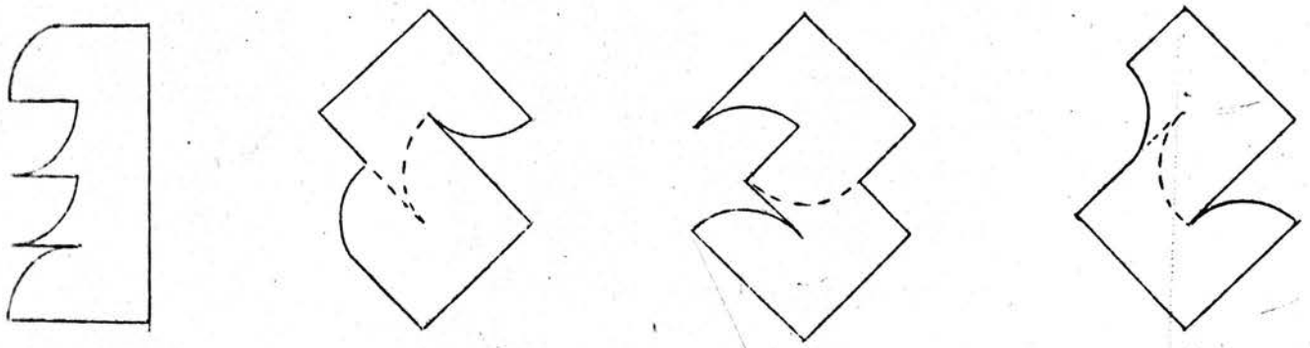


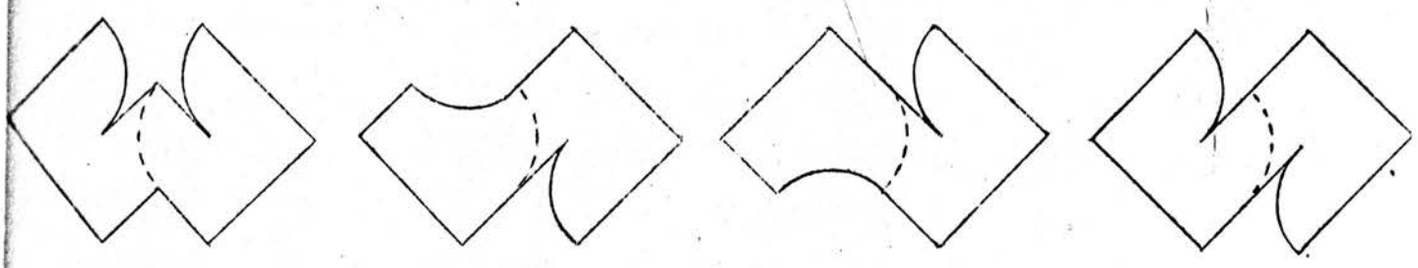
GO STRAIGHT ON TO PAGE 5

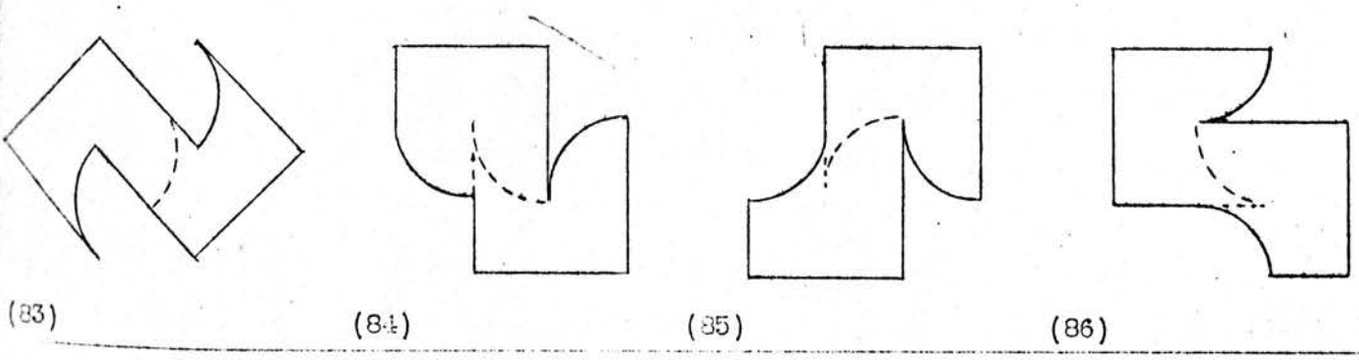












LOOK OVER YOUR WORK UNTIL TIME IS UP.

DO NOT TURN OVER OR OPEN THIS BOOK UNTIL YOU ARE TOLD.

MORAY HOUSE EXPERIMENTAL

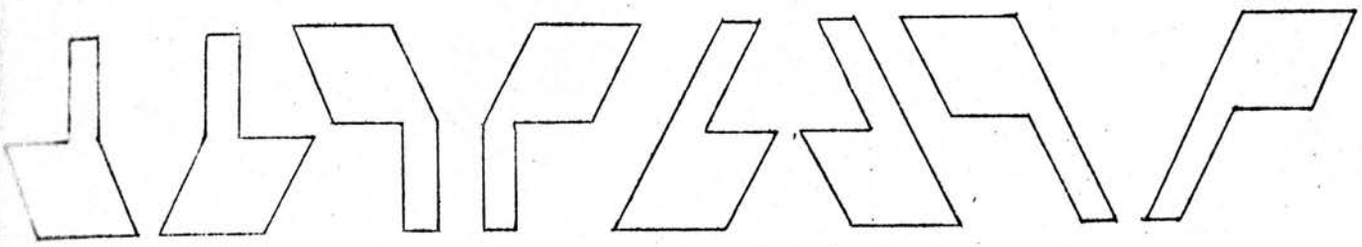
SPACE TEST 3R

Not to be filled in by the Scholar	
Age in years and completed months y. m.	
Page	Score
2.	
3.	
4.	
5.	
6.	
TOTAL	
Signature of Marker:	

Fill in the following particulars at once:-

1. Your Surname (In capital letters).....
2. Your Christian Name(s) (In capital letters).....
3. Sex (Boy or Girl).....
4. Name of your school.....
5. Class you are in.....
6. Your age.....years
7. Date of Your Birthday.....
8. Today's Date.....

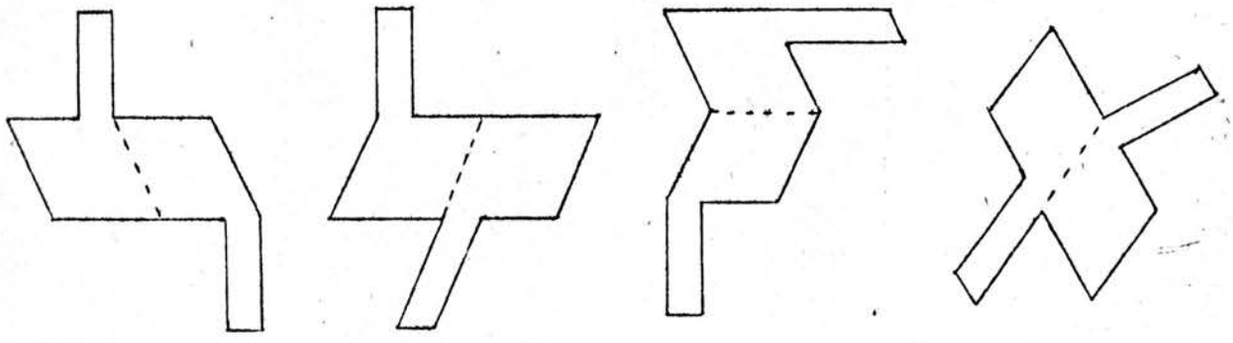
In the row below there are <u>eight</u> different shapes, lettered A, B, C, D, E, F, G, and H.



A B C D E F G H

Notice the difference between shapes A and B; C and D; E and F; G and H.

By moving the shapes <u>on the page</u>, we can fit two together and make a new drawing. In the next row, there are some drawings which have been made in this way.



(I) A C (2) B (3) E (4) G

In each drawing you are told what one of the shapes is, and you have to find the other and write its letter underneath.

The first question has been done for you. See if you can do the others.

Correct your answers. You should written the letter H under drawing Number 2 ; D under drawing Number 3 ; and C under drawing Number 4.

<u>Now read the following carefully.</u>

(I) All the questions that follow are like those you have just done.

(2) When you are told to begin, turn to page 2 and begin working at once.

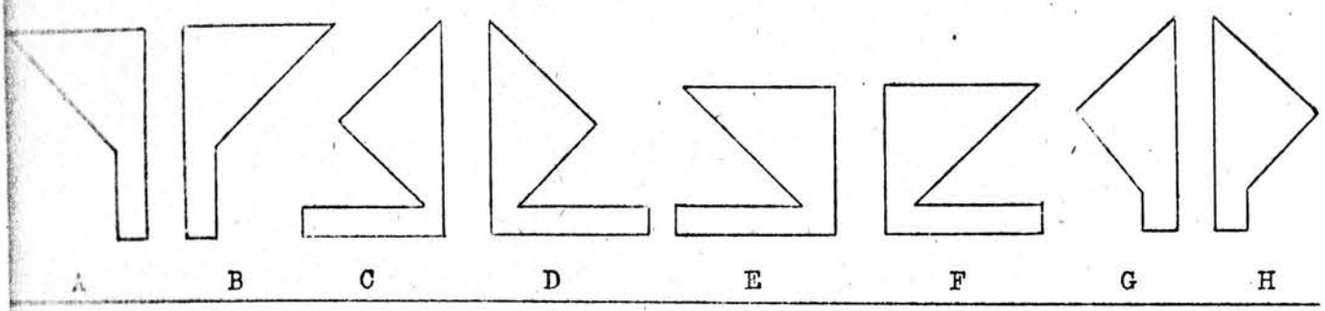
(3) Work as quickly and as carefully as you can.

(4) Make any alterations in your answers clearly.

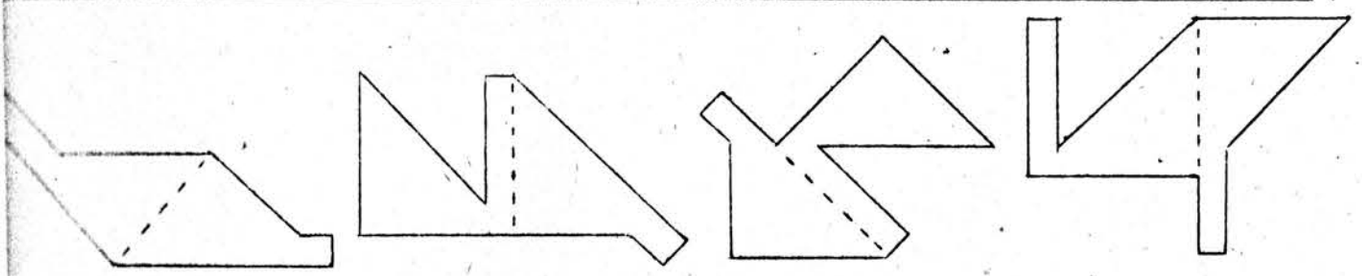
(5) You will have 40 minutes and you will be told the time every quarter of an hour. No one is expected to do everything. Just do as much as you can.

<u>DO NOT TURN OVER UNTIL YOU ARE TOLD.</u>

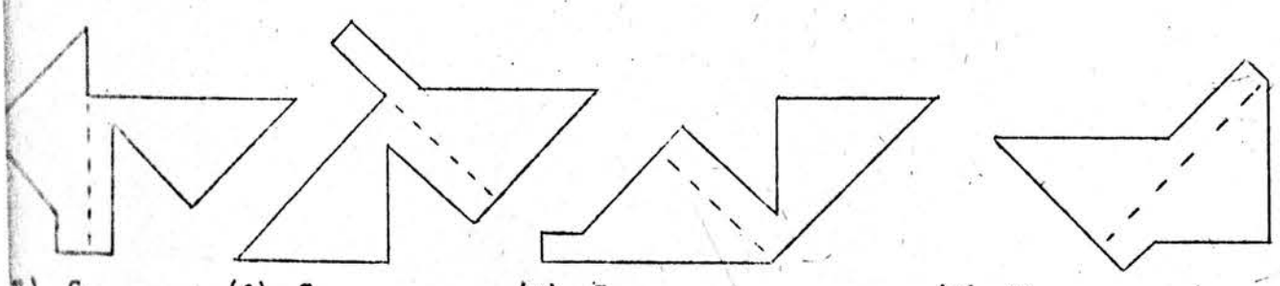
Do the questions below in the same way as those you have just done. In each drawing you are told what one of the shapes is, and you have to find the other and write its letter underneath.



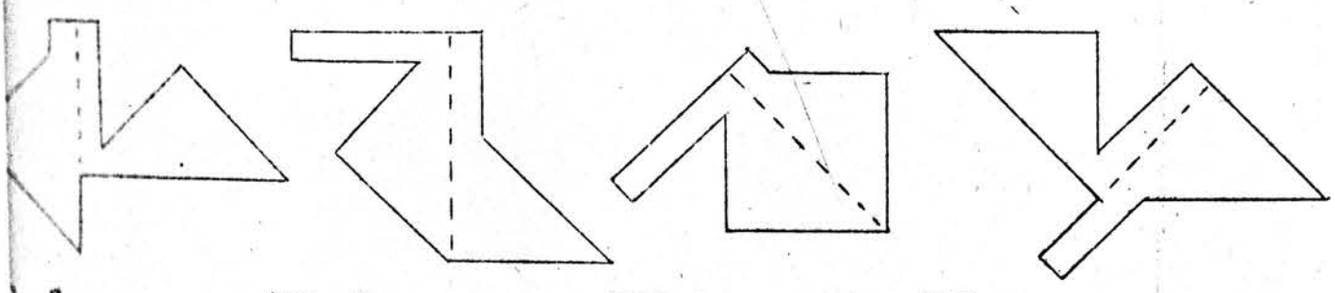
A B C D E F G H



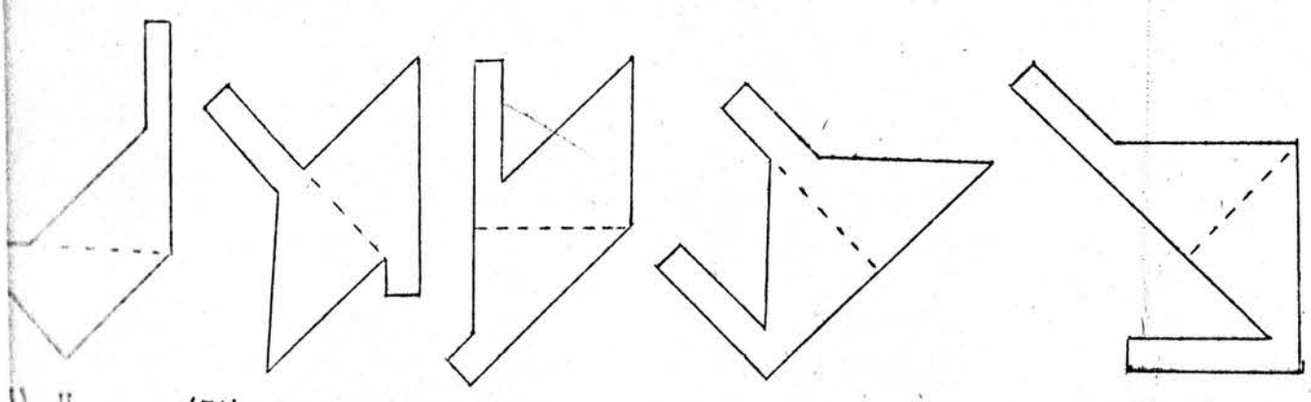
(I) A (2) F (3) H (4) B



5) G (6) C (7) C (8) H

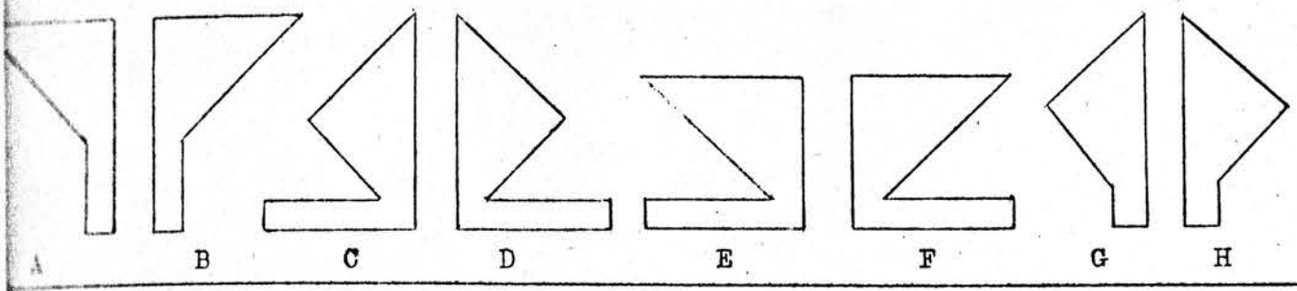


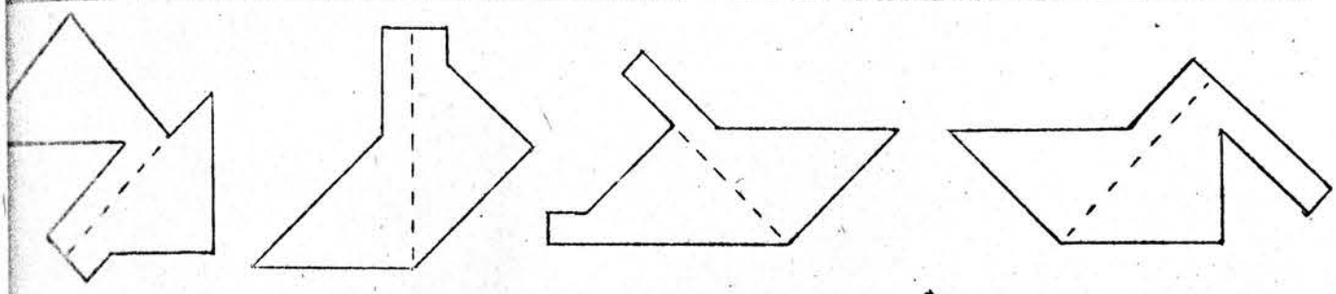
) C (I0) D (II) D (I2) B



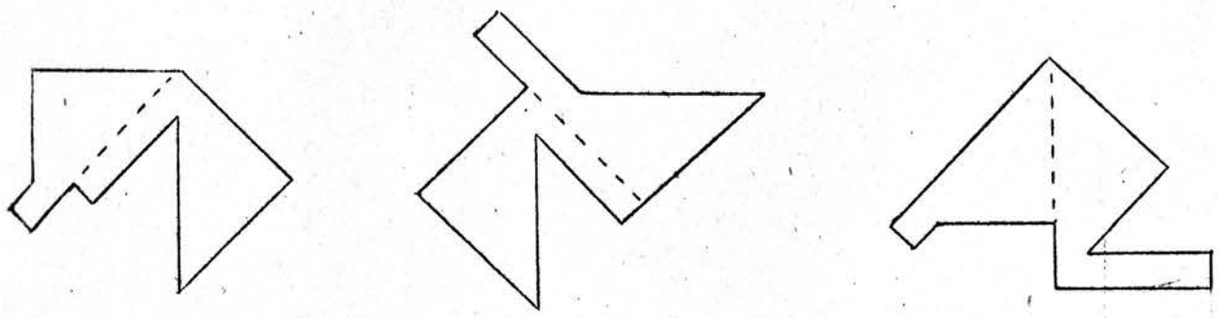
1) H (I4) G (I5) E (I6) E (I7) C

GO STRAIGHT ON TO PAGE 3.

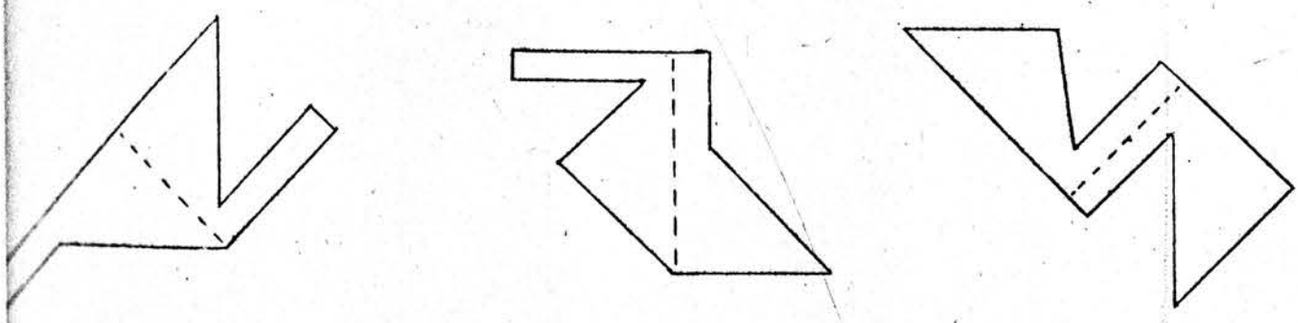




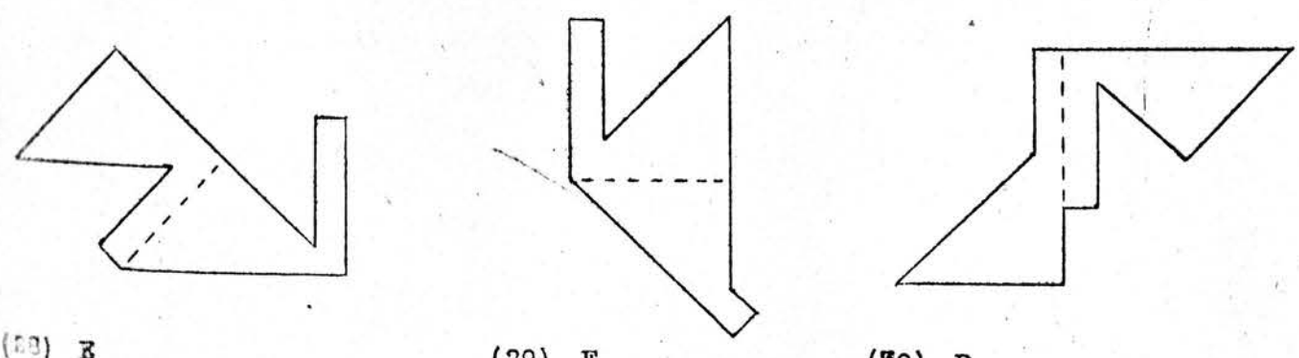
) H (I9) B (20) G (2I) B



(22) G (23) E (24) D

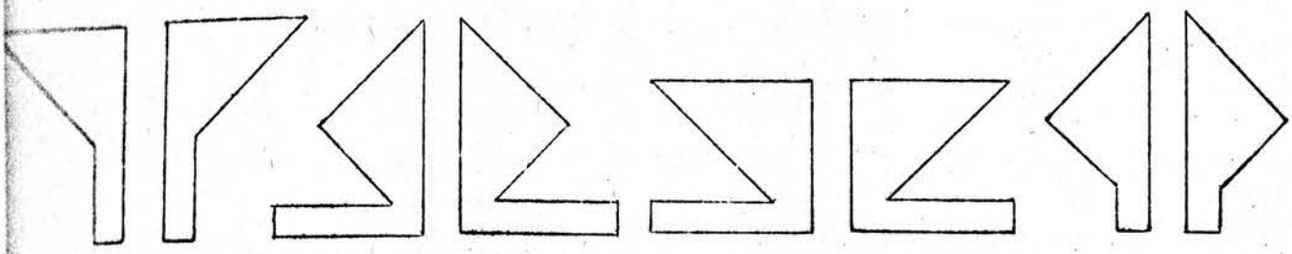


) F (26) A (27) F

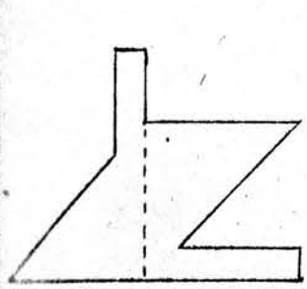


(28) E (29) E (30) D

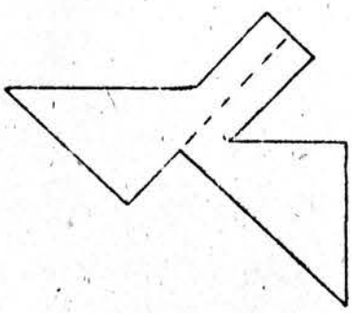
GO STRAIGHT ON TO PAGE 4



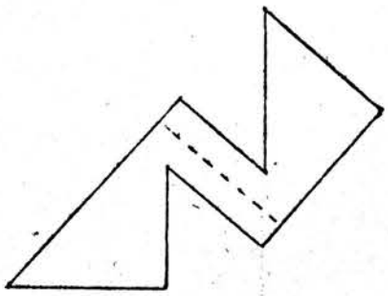
A B C D E F G H



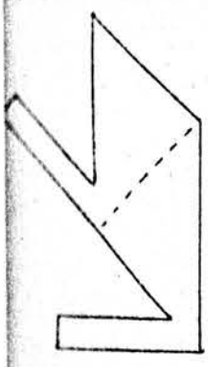
(31) F



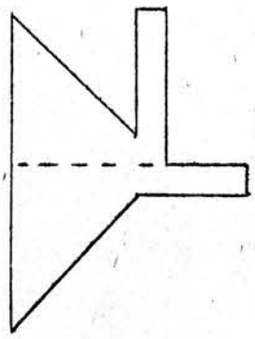
(32) B



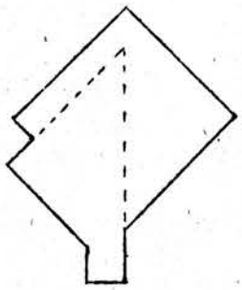
(33) C



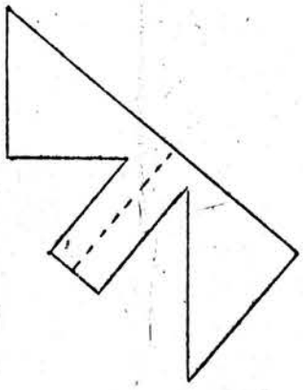
(34) E



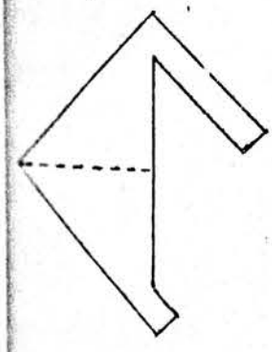
(35) A



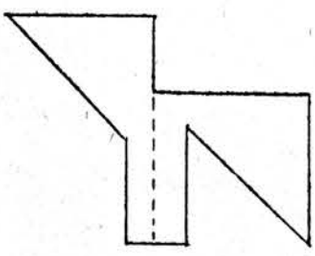
(36) G



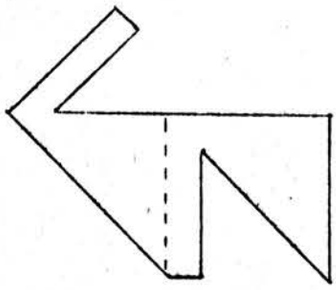
(37) F



(38) H



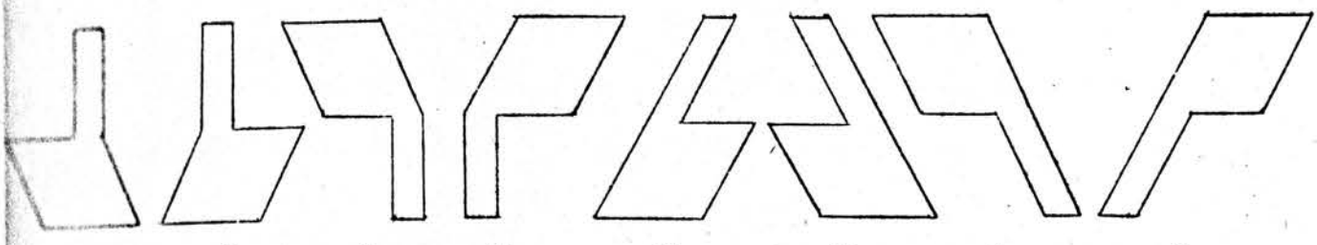
(39) A



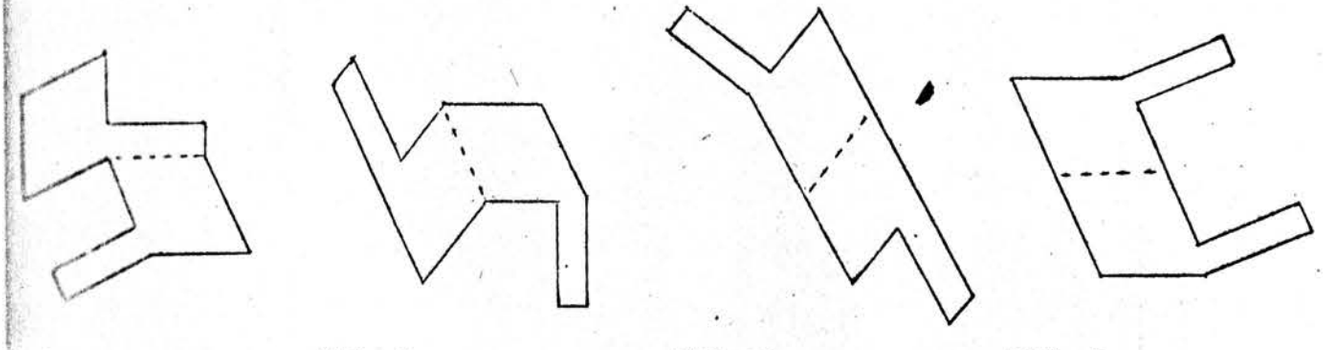
(40) F

GO STRAIGHT ON TO PAGE 5.

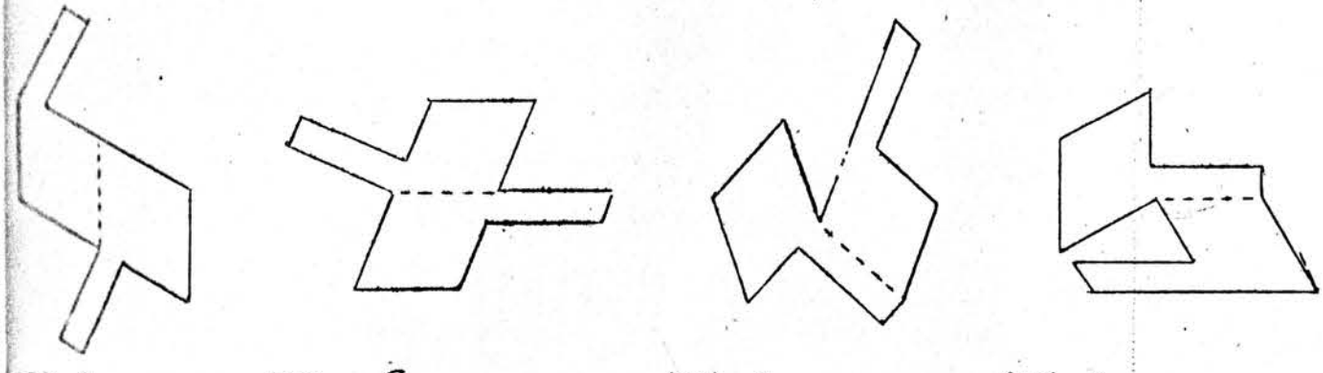
Do the questions below in the same way as those you have just done.



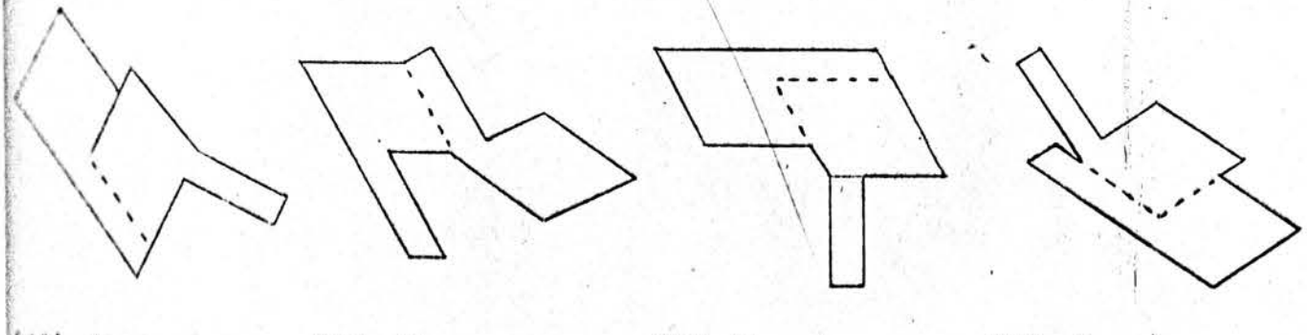
A B C D E F G H



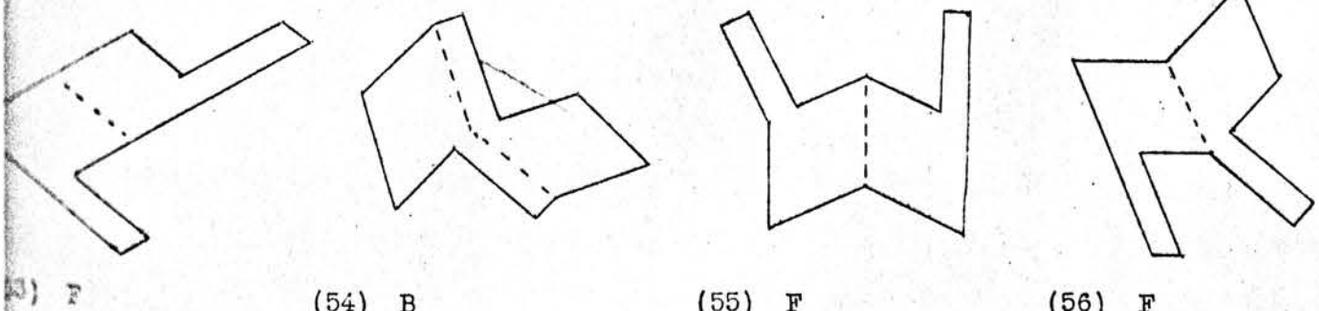
(41) A (42) C (43) E (44) D



(45) C (46) C (47) G (48) E

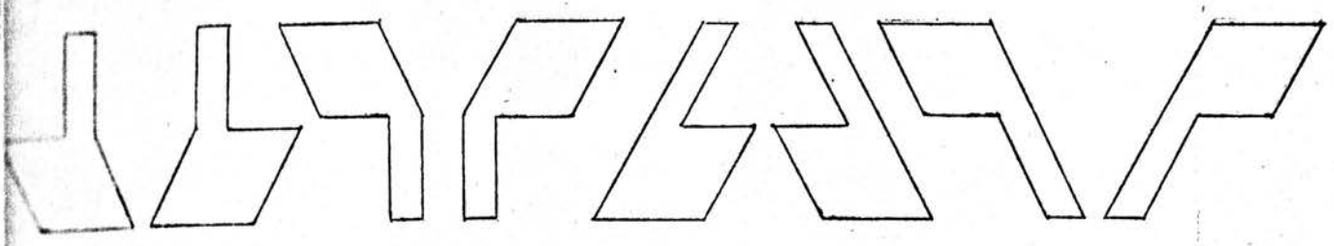


(49) H (50) F (51) E (52) G

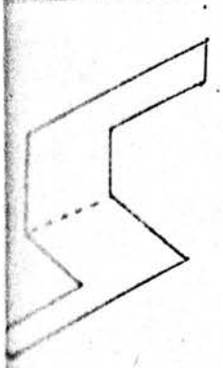


(53) F (54) B (55) F (56) F

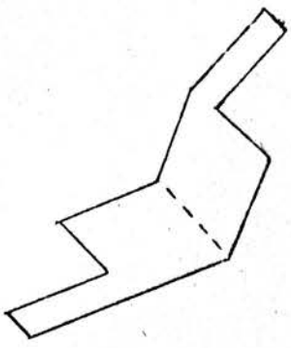
GO STRAIGHT ON TO PAGE 6.



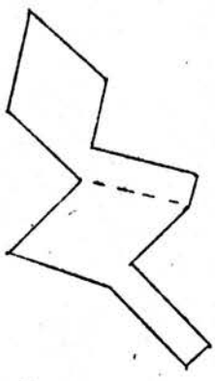
A B C D E F G H



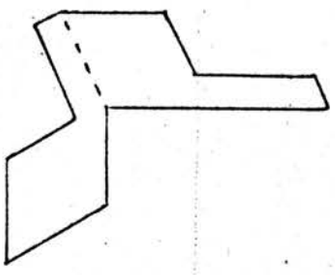
) C



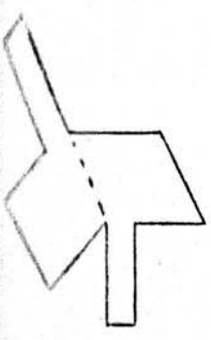
(58) C



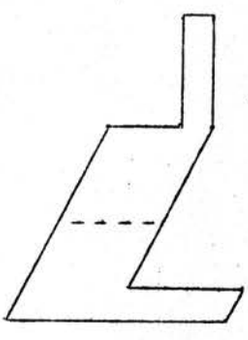
(59) D



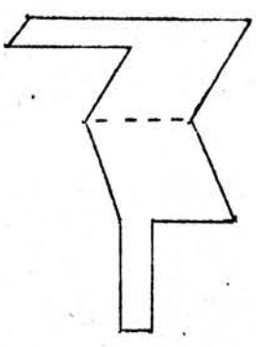
(60) H



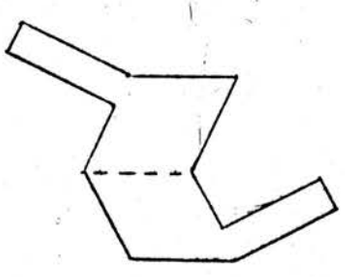
) A



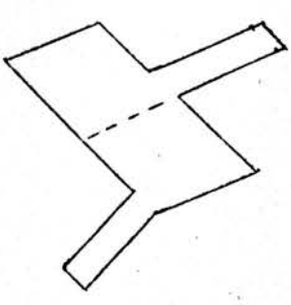
(62) F



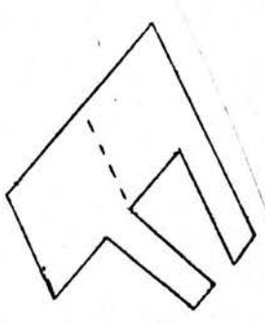
(63) A



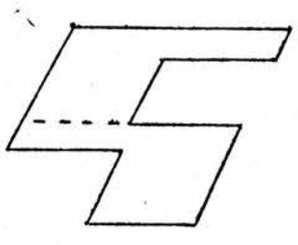
(64) D



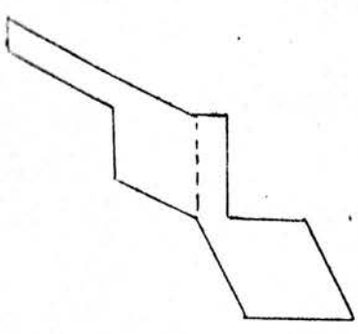
(65) H



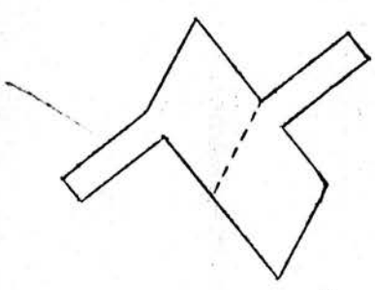
(66) B



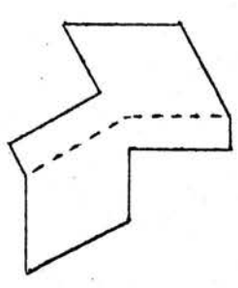
(67) F



(68) C



(69) A



(70) B

LOOK OVER YOUR WORK UNTIL TIME IS UP.

DO NOT TURN OVER OR OPEN THIS BOOK UNTIL YOU ARE TOLD.

MORAY HOUSE EXPERIMENTAL

S P A C E T E S T 4/R.

Not to be filled in by the Scholar	
Age in years and completed months. y. m.	
Page	Score
2	
3	
4	
5	
TOTAL	
Signature of marker.	

Fill in the following particulars at once:-

1. Your Surname (In capital letters).....
2. Your Christian Name(s) (In capital letters).....
3. Sex (Boy or Girl).....
4. Name of your school.....
5. Class you are in.....
6. Your Age.....years.
7. Date of Your Birthday.....
8. Today's Date.....

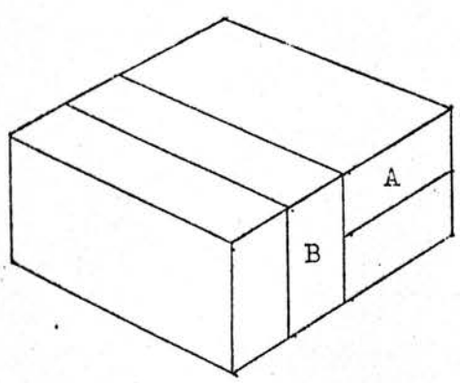
The drawings below show models which have been built with blocks. All the blocks are of the same shape and size. Notice that some of the blocks have been lettered.

You have to find out how many blocks are touched by each of the lettered blocks and write the answers in the blank spaces underneath.

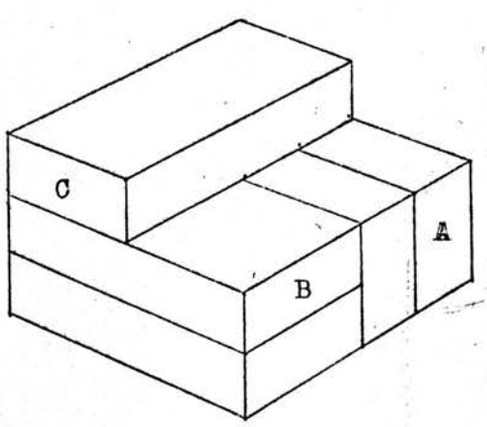
For example, in the first model, block A touches two other blocks; and so we have written 2, below A, in the blank space underneath the first drawing.

See if you can find out how many blocks are touched by block B, in the same model. Write the answer, below B, in the blank space underneath.

Now do the same for each of the lettered blocks in the second model. Make sure that you count all blocks touched by each lettered block.



A	B
2	



A	B	C

Correct your answers. You should have:-

A	B
2	3

and

A	B	C
2	3	3

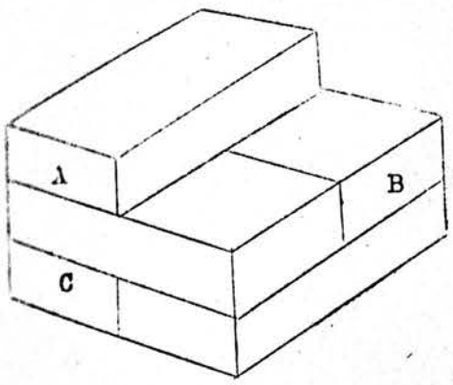
Now read the following carefully:-

1. All the questions that follow are like those you have just done.
2. When you are told to begin, turn over to page 2 and start working at once.
3. Work as quickly and as carefully as you can.
4. Make any alterations in your answers clearly.
5. You will have 30 minutes and you will be told the time after a quarter of an hour. No one is expected to do everything. Just do as much as you can.

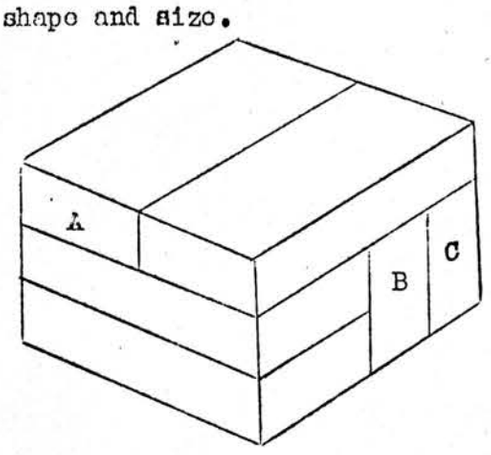
DO NOT TURN OVER UNTIL YOU ARE TOLD.

Write in the blank spaces below to show how many blocks <u>each</u> lettered block touches.

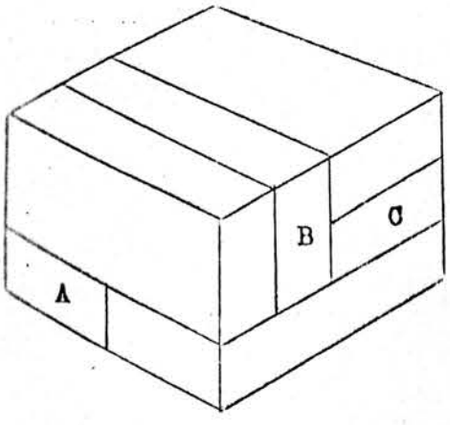
Remember the blocks are all of the same shape and size.



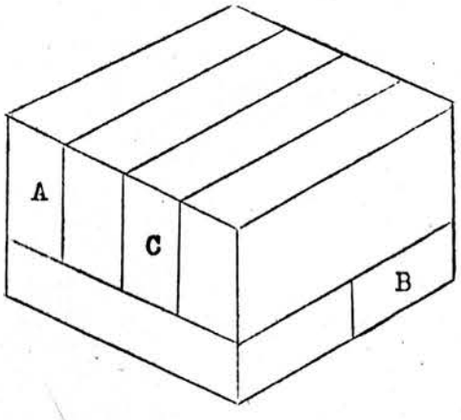
I	2	3
A	B	C



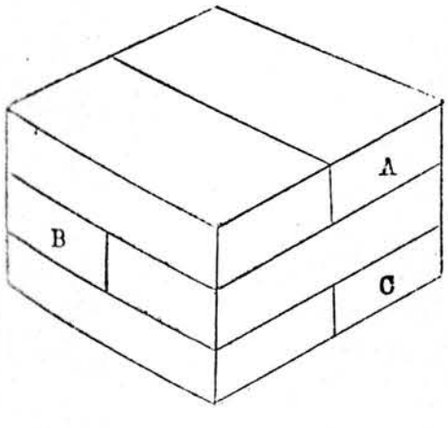
4	5	6
A	B	C



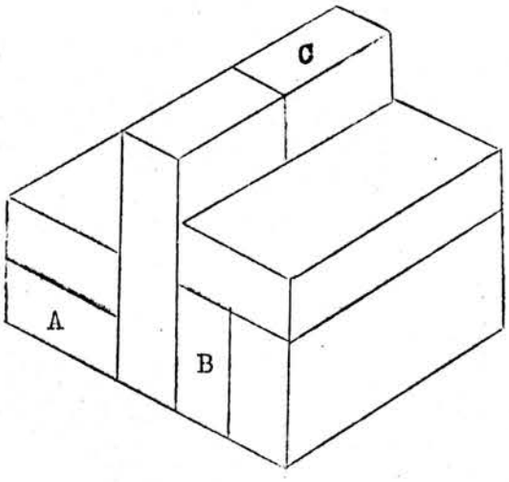
7	8	9
A	B	C



I0	II	I2
A	B	C

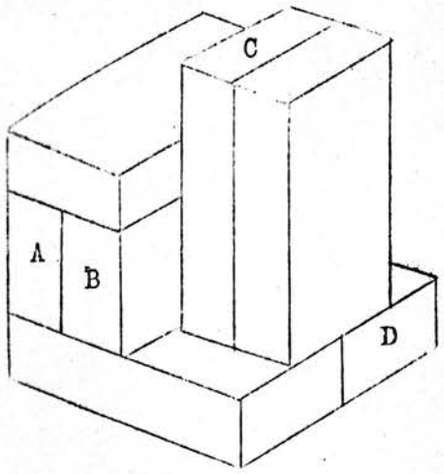


I3	I4	I5
A	B	C



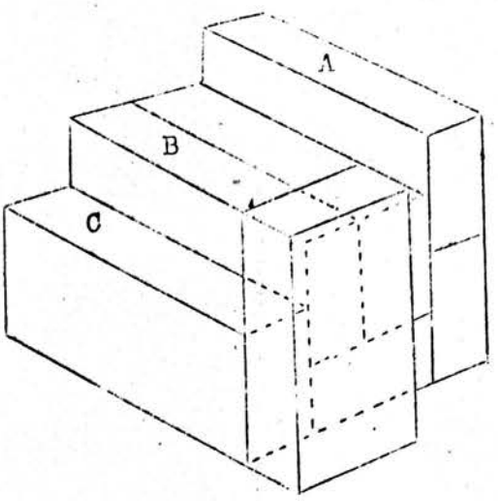
I6	I7	I8
A	B	C

GO STRAIGHT ON TO PAGE 3.



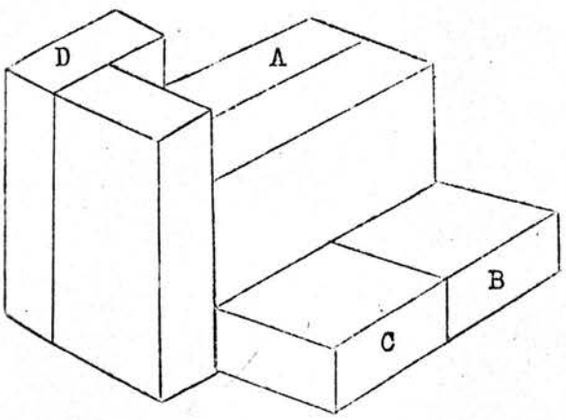
19 20 21 22

A	B	C	D



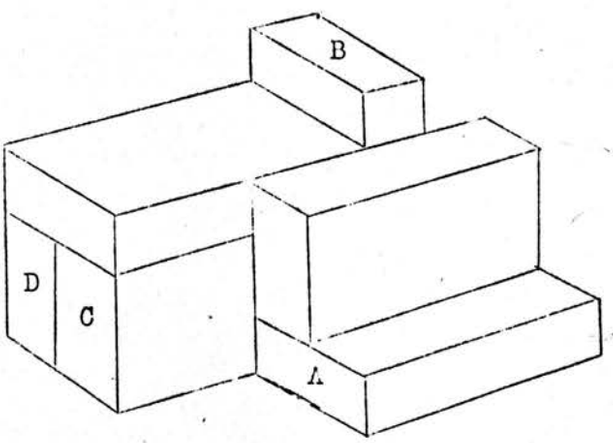
23 24 25

A	B	C



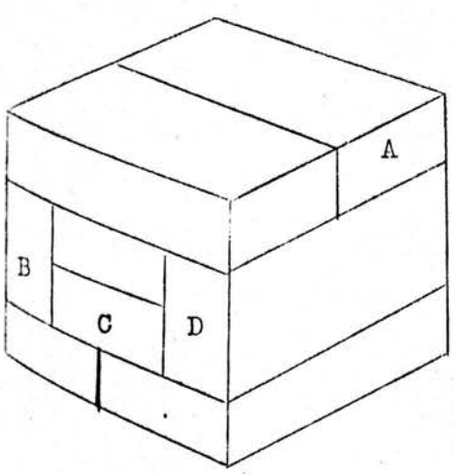
26 27 28 29

A	B	C	D



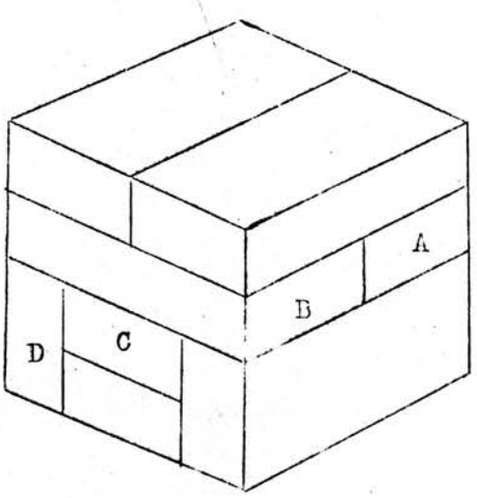
30 31 32 33

A	B	C	D



34 35 36 37

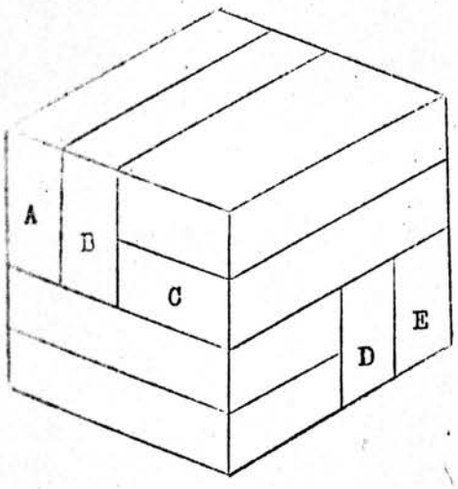
A	B	C	D



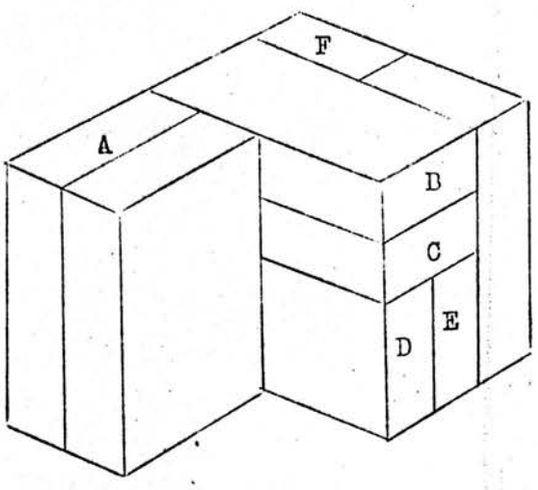
38 39 40 41

A	B	C	D

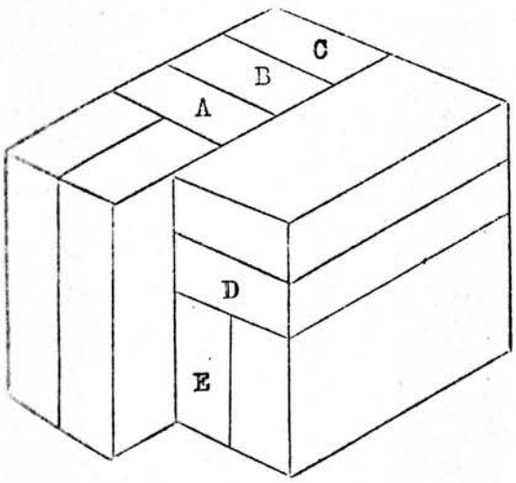
GO STRAIGHT ON TO PAGE 3



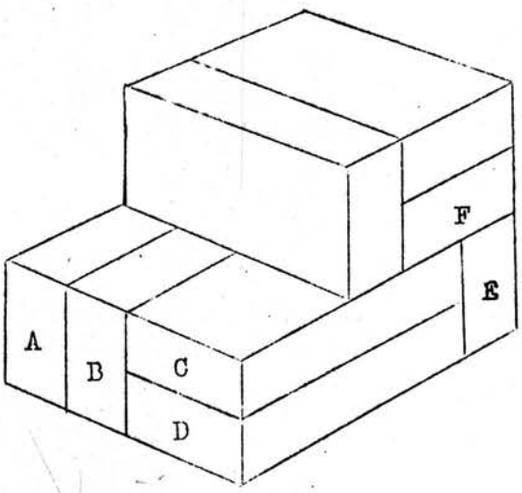
42	43	44	45	46
A	B	C	D	E



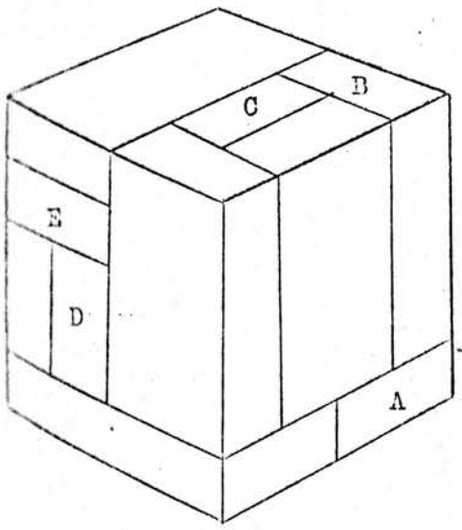
47	48	49	50	51	52
A	B	C	D	E	F



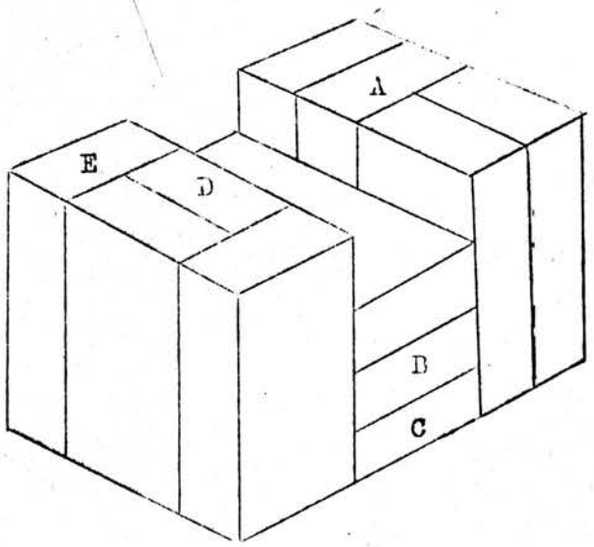
53	54	55	56	57
A	B	C	D	E



58	59	60	61	62	63
A	B	C	D	E	F

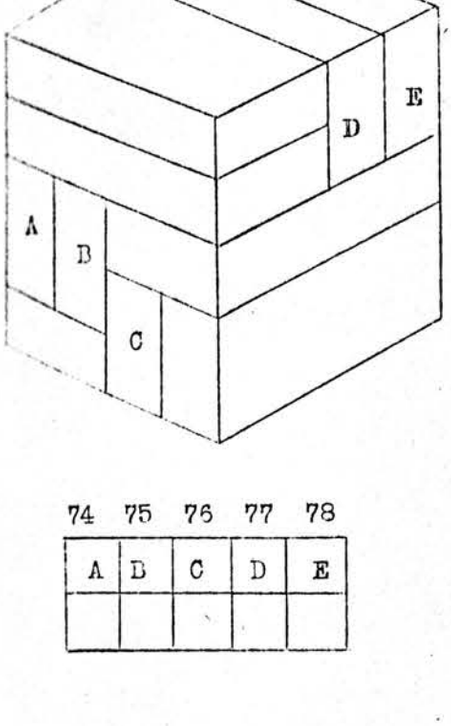


64	65	66	67	68
A	B	C	D	E

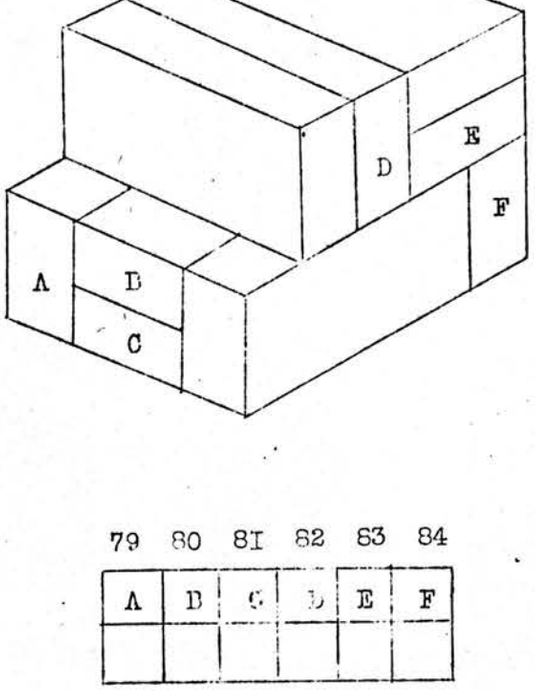


69	70	71	72	73
A	B	C	D	E

GO STRAIGHT ON TO PAGE 5.



74	75	76	77	78
A	B	C	D	E



79	80	81	82	83	84
A	B	C	D	E	F

85	86	87	88	89	90	91	92
A	B	C	D	E	F	G	H

93	94	95	96	97	98	99	100
A	B	C	D	E	F	G	H

LOOK OVER YOUR WORK UNTIL TIME IS UP.

DO NOT TURN OVER OR OPEN THIS BOOK UNTIL YOU ARE TOLD.

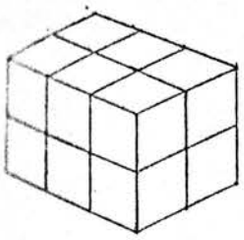
MORAY HOUSE EXPERIMENTAL

SPACE TEST 5/R

Not to be filled in by the Scholar	
Age in years and completed months y. m.	
Page	Score
2.	
3.	
4.	
5.	
6.	
TOTAL	
Signature of Marker:	

Fill in the following particulars at once:-

1. Your Surname (In capital letters).....
2. Your Christian Name(s) (In capital letters).....
3. Sex (Boy or Girl).....
4. Name of your school.....
5. Class you are in.....
6. Your age.....years
7. Date of Your Birthday.....
8. Today's Date.....



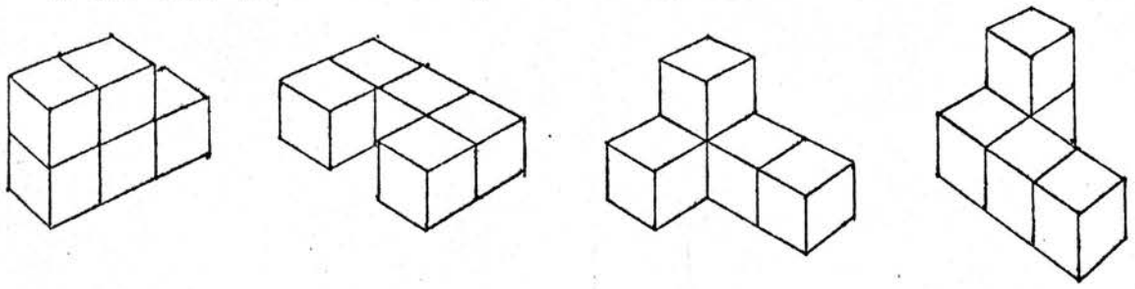
Look at the drawing at the top of the page.
It shows an oblong block made of small cubes.

Now look at the drawings below. They show parts of an oblong block like the one shown above. Notice that the four parts above the double line are lettered A, B, C and D, while the five parts below the double line are numbered I, 2, 3, 4 and 5.

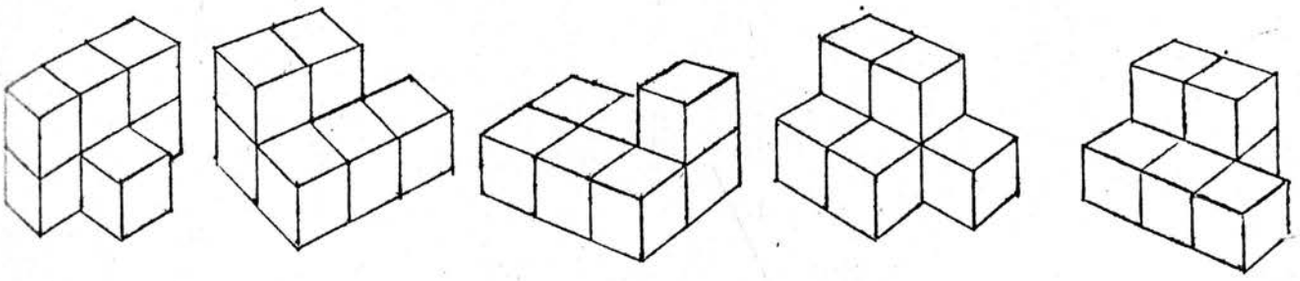
You have to find out which of the lettered parts will fit exactly each of the numbered parts to make an oblong block like that at the top of the page.

For example, part B will fit exactly part Number I, and so we have written the letter B on the line underneath.

Notice that none of the other lettered parts will fit part Number I exactly.



A B C D



I) B (2) (3) (4) (5)

For each of the numbered parts 2, 3, 4 and 5, write on the line underneath the letter of the part needed to make an oblong block like that shown at the top of the page.

The parts may be turned over into any position but they must fit exactly.

A lettered part may be used more than once.

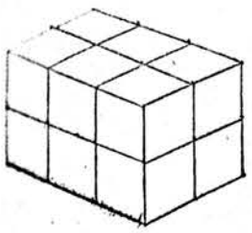
Correct your answers. You should have:-

(2) D. (3) A. (4) C. (5) D.

Now read the following carefully:-

1. All the questions that follow are like those you have just done.
2. When you are told to begin, turn to page 2 and begin working at once.
3. Work as quickly and as carefully as you can.
4. Make any alterations in your answers clearly.
5. You will have 45 minutes and you will be told the time every quarter of an hour. No one is expected to do everything. Just do as much as you can.

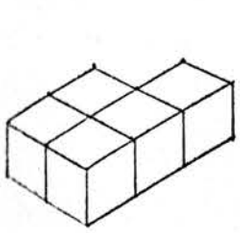
DO NOT TURN OVER UNTIL YOU ARE TOLD.



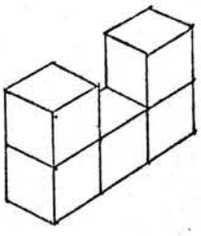
Do the questions below in the same way as those you have just done. On the line under each numbered block, write the letter of the part needed to make an oblong block like that shown at the top of the page.

The parts can be turned over into any positions, but they must fit exactly.

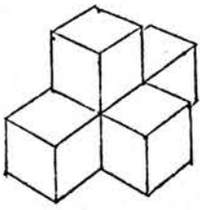
Each lettered part may be used more than once.



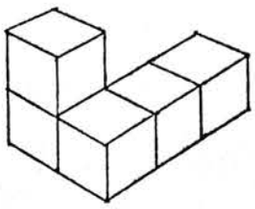
A



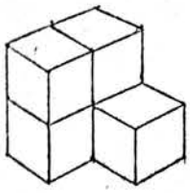
B



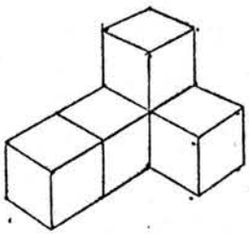
C



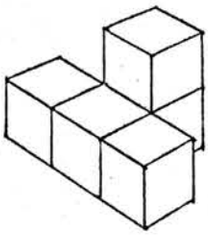
D



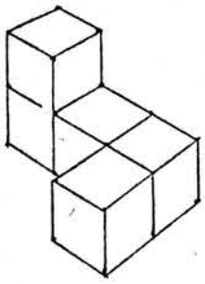
E



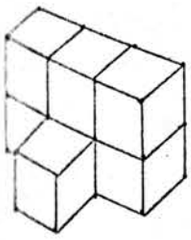
F

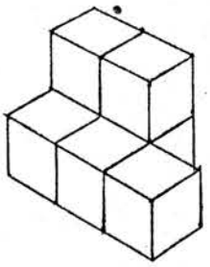


G



H





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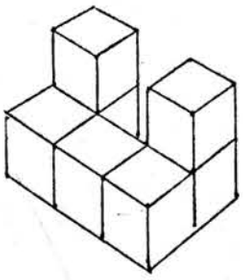
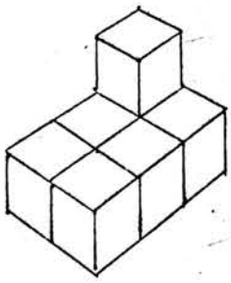
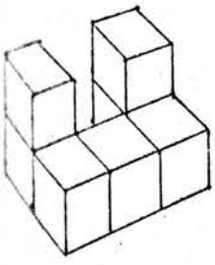
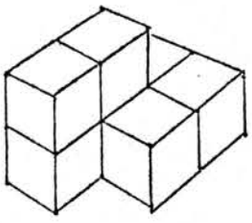


(3)

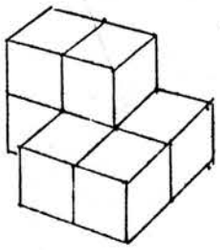


(4)

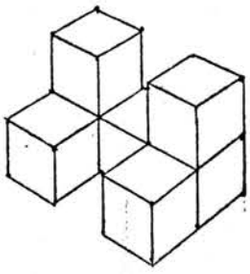




(6)



(7)



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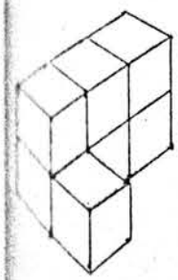
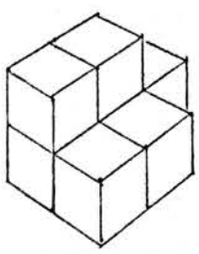
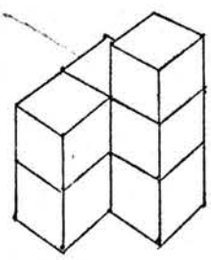
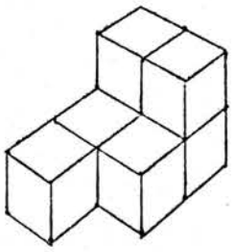




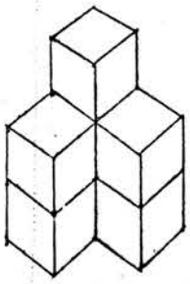
(I0)



(II)

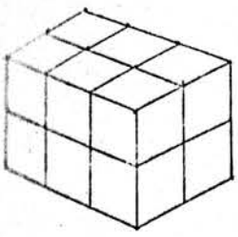


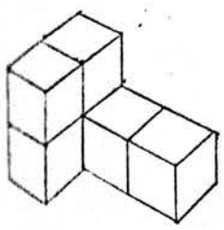
(I2)



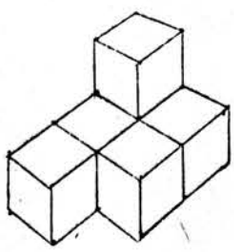
(I3)

GO STRAIGHT ON TO PAGE 3.

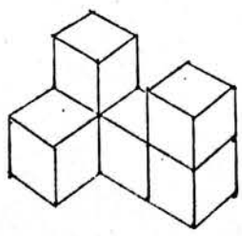




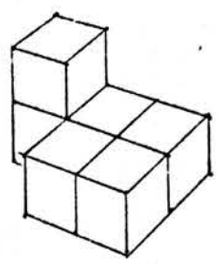
A



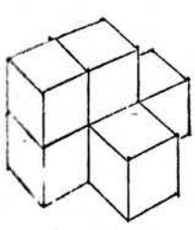
B



C



D



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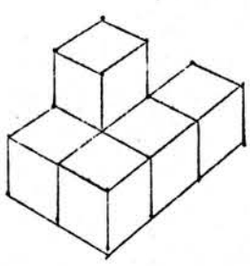

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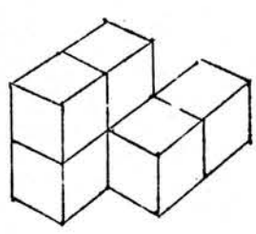

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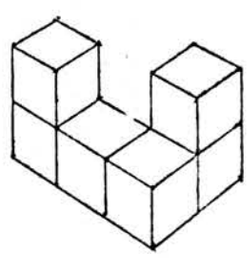

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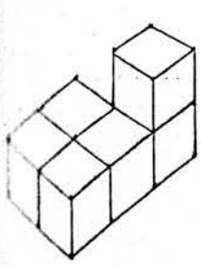

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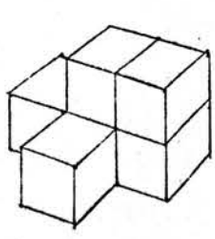

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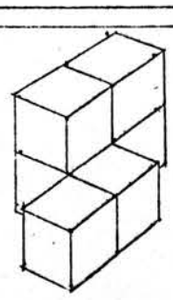

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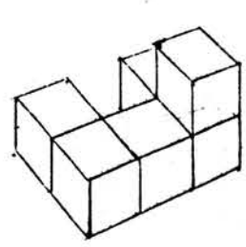

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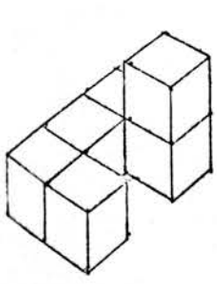

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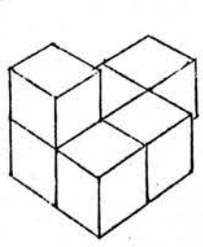

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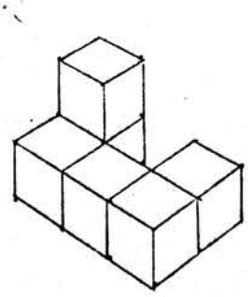

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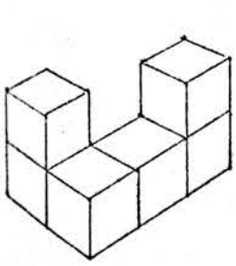

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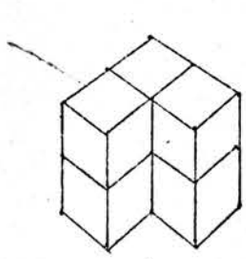

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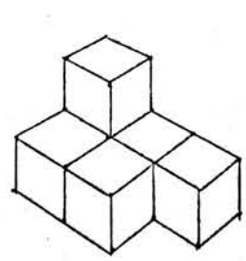

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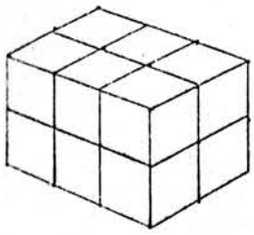

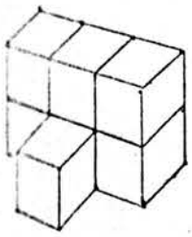

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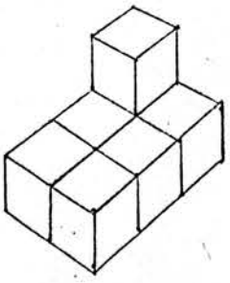

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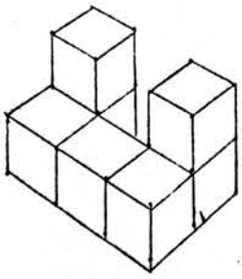

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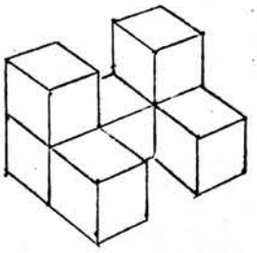

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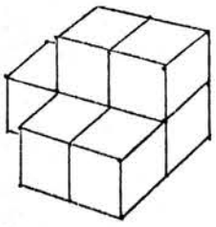

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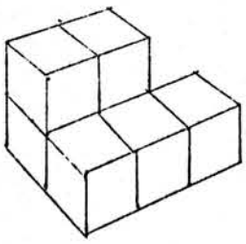

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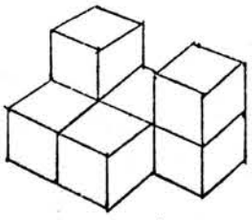

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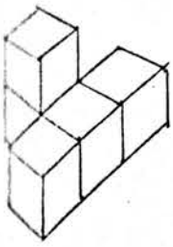

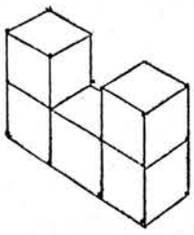

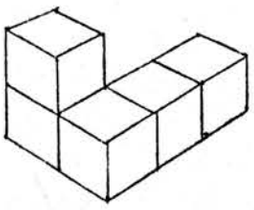

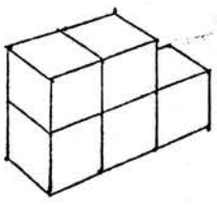

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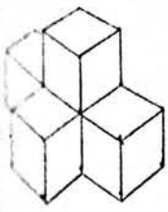

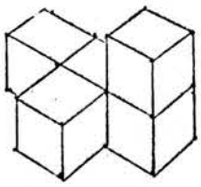

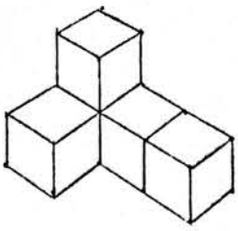

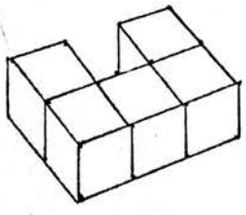

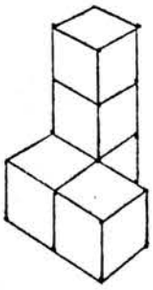

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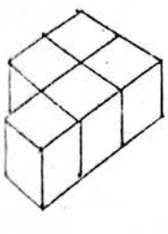

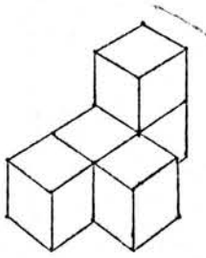

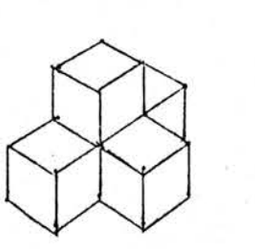

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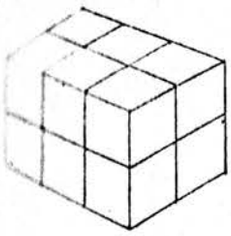

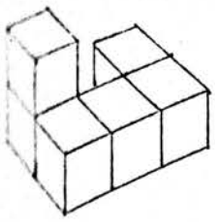

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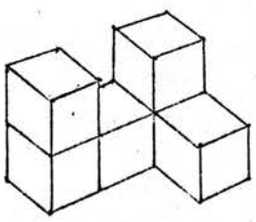

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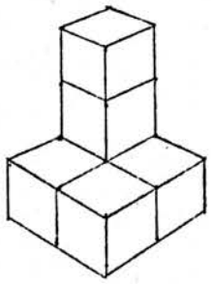

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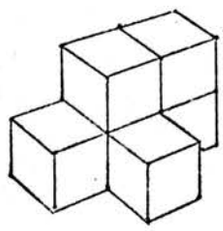

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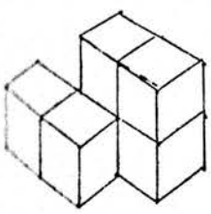

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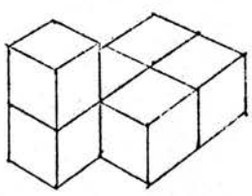

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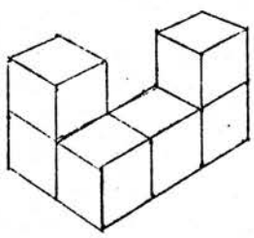

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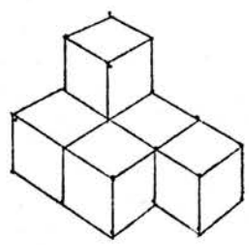

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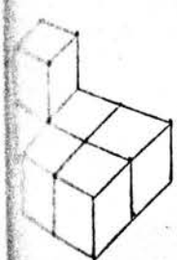

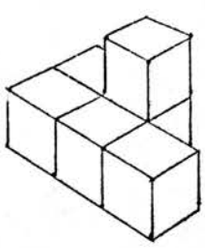

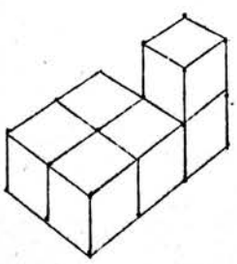

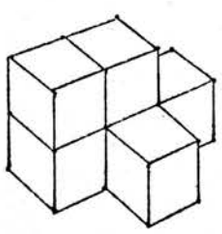

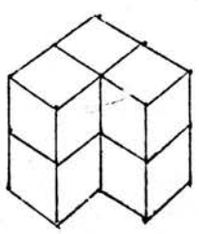

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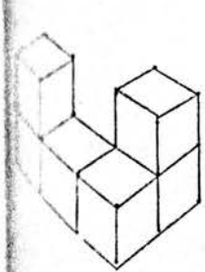

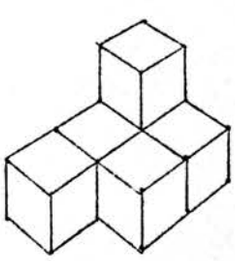

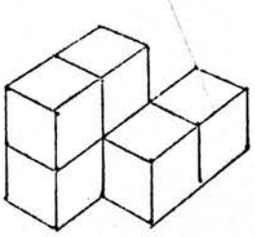

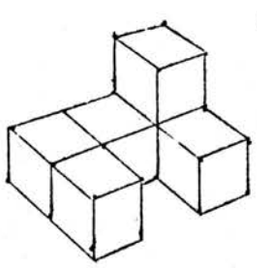

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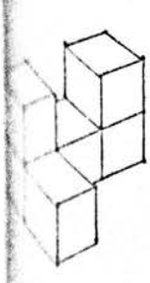

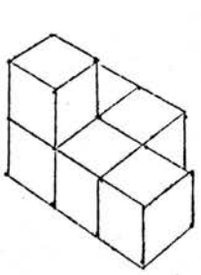

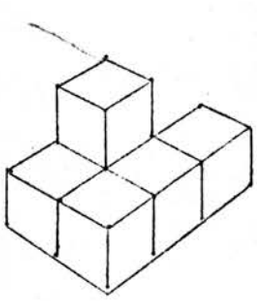

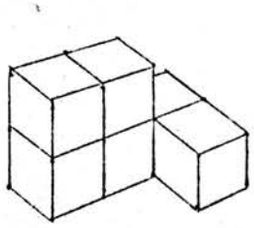

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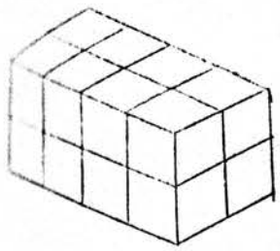

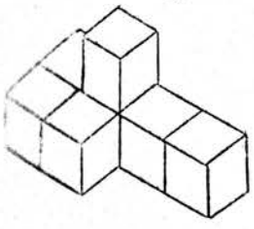

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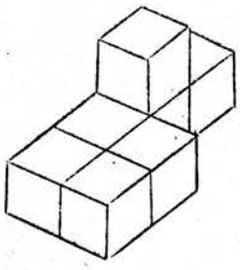

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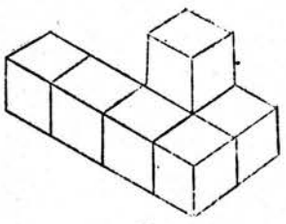

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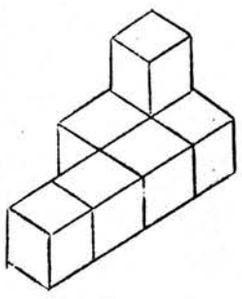

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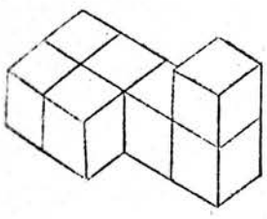

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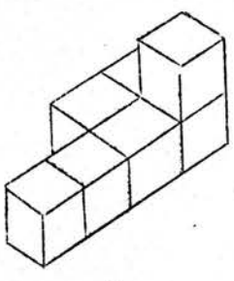

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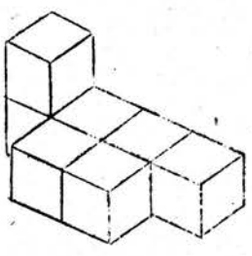

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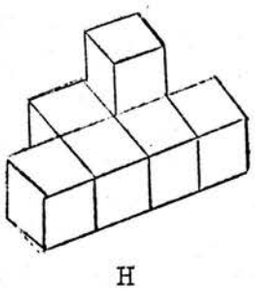

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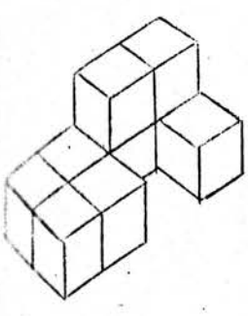

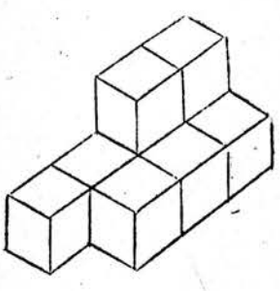

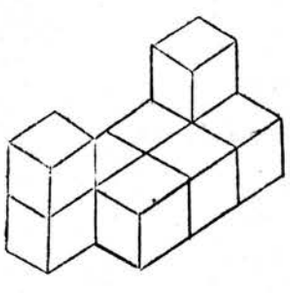

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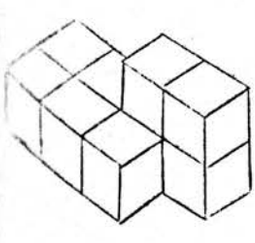

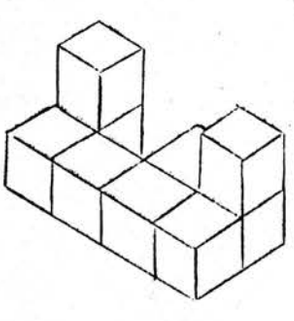

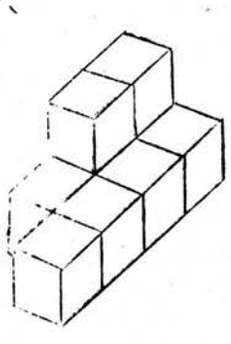

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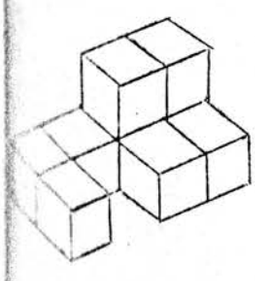
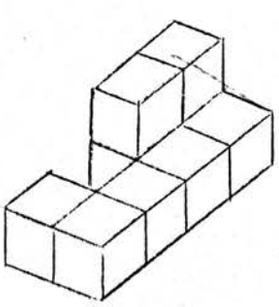
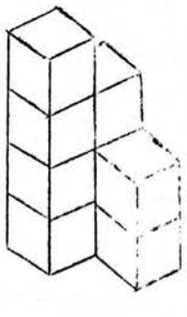
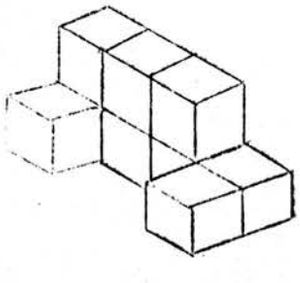








(58) (59) (60)

LOOK OVER YOUR WORK UNTIL TIME IS UP.

DO NOT TURN OVER OR OPEN THIS BOOK UNTIL YOU ARE TOLD.

M O R A Y H O U S E E X P E R I M E N T A L

S P A C E T E S T 6/R

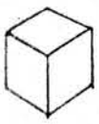
Not to be filled in by the Scholar.	
Age in years and completed months y. m.	
Page	Score
2	
3	
TOTAL	
Signature of marker:	

Fill in the following particulars at once:-

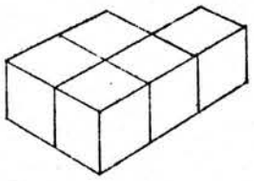
1. Your Surname (In capital letters).....
2. Your Christian Name(s) (In capital letters).....
3. Sex (Boy or Girl).....
4. Name of your school.....
5. Class you are in.....
6. Your Age.....years.
7. Date of Your Birthday.....
8. Today's Date.....

Look at drawing Number I below. It shows a cube. A cube has six sides or faces.

Now look at drawing Number 2. It shows a model which has been made by gluing together five cubes.



Drawing. Number I.



Drawing Number 2.

I	2	3	4	5
0	1			

Suppose the model in drawing Number 2 has been painted on all sides except the bottom. You have to find out how many of its cubes have paint on one face only; how many have paint on two faces only; and so on.

For example, in the model shown in drawing Number 2, there are no cubes having paint on one face only, and so we have placed 0 in column I at the side of the model. There is one cube having paint on two faces only, and so we have placed I in column 2 at the side of the model.

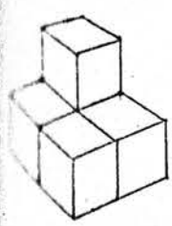
See if you can find out how many cubes there are having paint on three faces only. Write the answer in column 3 at the side of the model.

Do the same for cubes having paint on four faces only and for cubes having paint on five faces only.

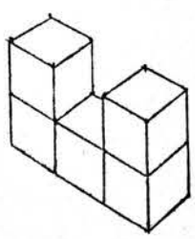
Correct your answers. You should have written 3 in column 3; I in column 4; and 0 in column 5.

For each of the models shown in drawings 3, 4, and 5 below, write in column I at the side to show how many cubes have paint on one face; in column 2 to show how many cubes have paint on two faces; and so on.

Remember that the models are painted on all sides except the bottom.



(3)



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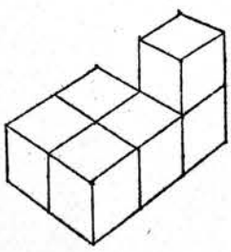


(5)

	I	2	3	4	5
(3)					
(4)					
(5)					

Correct your answers. You should have:-

	I	2	3	4	5
(3)	0	1	3	0	1
(4)	0	0	3	0	2
(5)	0	1	4	0	1

Now read the following carefully:-

I. All the questions that follow are like those you have just done.

2. When you are told to begin, turn to page 2 and start working at once.

3. Work as quickly and as carefully as you can.

4. Make any alterations in your answers clearly.

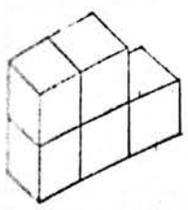
5. You will have 30 minutes and you will be told the time after a quarter of an hour. No one is expected to do everything. Just do as much as you can.

DO NOT TURN OVER UNTIL YOU ARE TOLD.

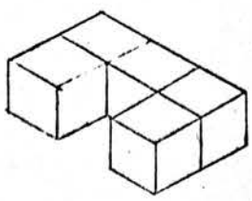
For each model below, write in column I to show how many cubes have paint on one face; write in column 2 to show how many cubes have paint on two faces; and so on.

Some of the questions have been done for you. You do the others.

Remember that the models are painted on all sides except the bottom.



(I)



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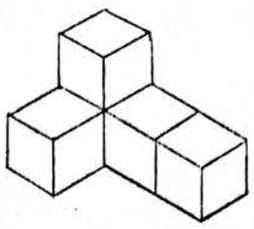

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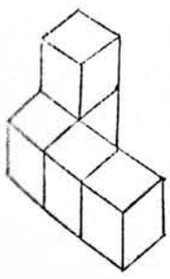

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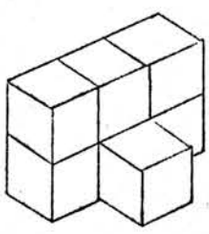

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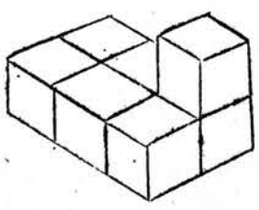

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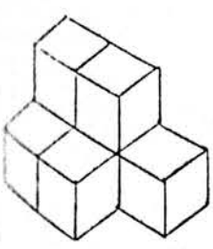

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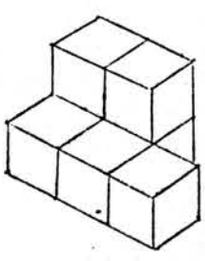

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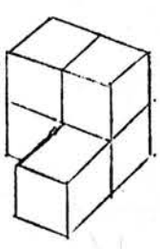

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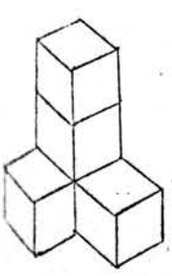

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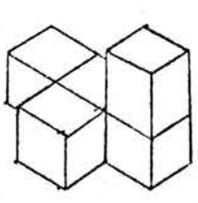

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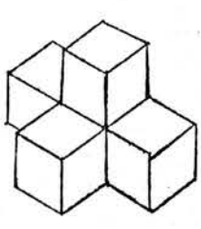

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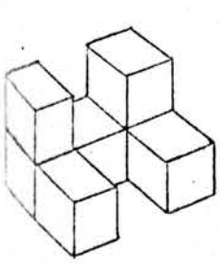

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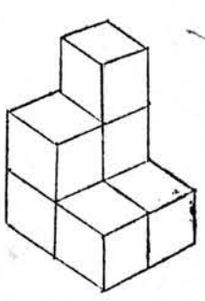

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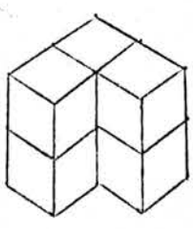
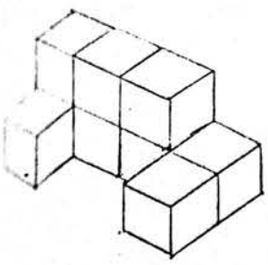


(I5)

	I	2	3	4	5
(I)	0				
(2)			3		0
(3)	0	I			
(4)				I	
(5)	I				
(6)					
(7)			2		0
(8)					0
(9)	0				
(I0)	0	I			
(II)					I
(I2)					
(I3)					
(I4)					
(I5)	0				

GO STRAIGHT ON TO PAGE 3.



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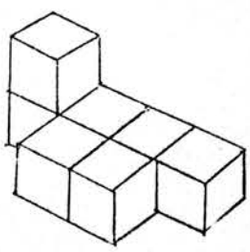

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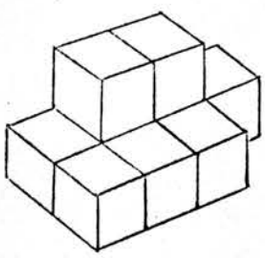

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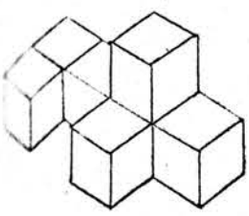

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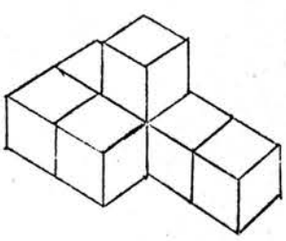

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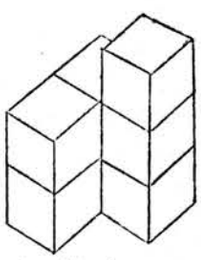

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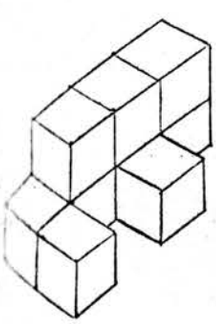

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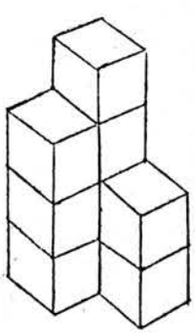

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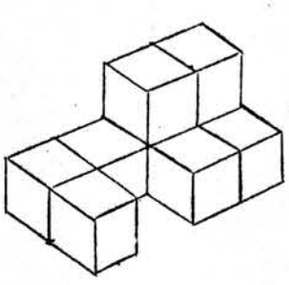

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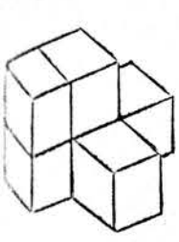

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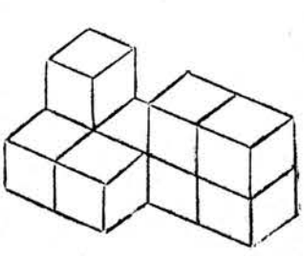

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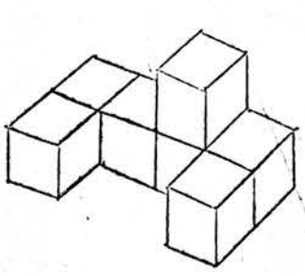

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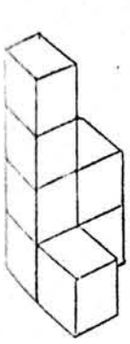

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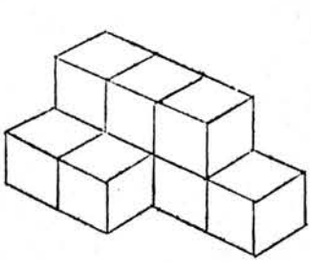

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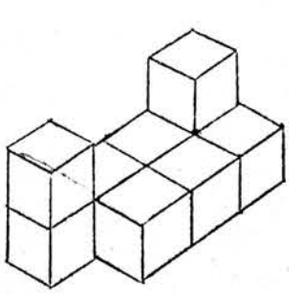

(30)

	I	2	3	4	5
(I6)	0				
(I7)				I	
(I8)					0
(I9)		0			
(20)				I	I
(2I)	0			I	I
(22)					0
(23)	0			2	
(24)					0
(25)		0			0
(26)				2	I
(27)					I
(28)	0				I
(29)					0
(30)	0				

LOOK OVER YOUR WORK UNTIL TIME IS UP.

DO NOT TURN OVER OR OPEN THIS BOOK UNTIL YOU ARE TOLD.

M O R A Y H O U S E E X P E R I M E N T A L

S Y N O N Y M S T E S T I/R

Not to be filled in by the Scholar	
Age in years and completed months y. m.	
Page	Score
2.	
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TOTAL	
Signature of Marker:	

Fill in the following particulars at once:-

1. Your Surname (In capital letters).....
2. Your Christian Name(s) (In capital letters).....
3. Sex (Boy or Girl).....
4. Name of your school.....
5. Class you are in.....
6. Your age.....years
7. Date of Your Birthday.....
8. Today's Date.....

In this test, you have to underline in the brackets the word which means most nearly the SAME as the word in capital letters.

Here is an example:

Although he has done me harm, I shall PARDON him.

(punish / love / reward / forgive / hit / please)

"Pardon" means nearly the same as "forgive", and so we have underlined "forgive" in the brackets.

Now do the questions below in the same way. Underline in the brackets the word which means most nearly the SAME as the word in capital letters.

1. The king GOVERNED his people justly.

(taught / judged / obeyed / released / ruled / encouraged)

2. Alice heard MOCKING laughter.

(hearty / childish / silent / muffled / hysterical / jeering)

3. His speech CONCLUDED the conference.

(began / ended / amused / upset / astonished / horrified)

Correct your answers. You should have underlined the words: (1) ruled, (2) jeering, and (3) ended.

Now read the following carefully:-

1. All the questions in this test are like those you have just done.

2. When you are told to begin, turn to page 2 and start working at once.

3. Work as quickly and as carefully as you can.

4. Make any alterations in your answers clearly.

5. You will be allowed 20 minutes.

DO NOT TURN OVER UNTIL YOU ARE TOLD.

Do the questions below in the same way as those you have just done. Underline in the brackets the word or phrase which means most nearly the SAME as the word in capital letters.

1. Before it would return, the dog had to be COAXED.

(found / beaten / fed / muzzled / persuaded / coached)

2. The hen was surrounded by NUMEROUS chickens.

(tiny / many / fluffy / yellow / frightened / her own)

3. This is a VALUABLE ring.

(useless / lovely / precious / ugly / cheap / variable)

4. She was trying to UNRAVEL the wool.

(spin / knit / weave / disentangle / wind / reveal)

5. There were two VACANT desks in the schoolroom.

(broken / carved / wooden / uncomfortable / occupied / empty)

6. Smoking is PROHIBITED in the factory.

(enjoyed / forbidden / promoted / allowed / disliked / hindered)

7. They were CONFIDENT they would succeed.

(confidential / informed / delighted / afraid / doubtful / sure)

8. There is no REMEDY for this disease.

(cure / name / hospital / help / doctor / hope)

9. The onlookers were full of COMPASSION for the poor dog.

(envy / horror / gratitude / pity / dislike / interest)

10. You will be better after you have had some NOURISHMENT.

(food / instruction / practice / massage / exercise / sleep)

11. The mammoth was a GIGANTIC creature.

(romantic / enormous / ancient / prehistoric / remarkable / unique)

12. Bad weather made the farmers GRUMBLE.

(furious / hopeful / anxious / relax / complain / work)

13. Ants are INDUSTRIOUS insects.

(small / numerous / poisonous / injurious / hard-working / harmless)

14. This is a very DANGEROUS climb.

(steep / difficult / cunning / rocky / rough / perilous)

GO STRAIGHT ON TO PAGE 3.

15. Long ago Englishmen DREADED the plague.

(enjoyed / ignored / fought / feared / caught / died of)

16. The house is FILTHY.

(clean / healthy / black / untidy / disgraceful / dirty)

17. An EMINENT doctor was summoned.

(foreign / distinguished / energetic / clever / elderly / animal)

18. "You are too INQUISITIVE," she said.

(kind / conceited / rash / curious / early / exquisite)

19. Our school goes for a picnic ANNUALLY.

(every week / once a month / every year / after the examinations / excitedly / all together)

20. The CONTINUOUS rain prevented us from going out.

(heavy / continental / ceaseless / slight / pouring / intermittent)

21. A CELEBRATED actress appeared in the new play.

(celibate / famous / beautiful / unknown / foreign / film)

22. These pearls are GENUINE.

(pink / artificial / real / genteel / expensive / stolen)

23. He refused to desert his COMRADES.

(enemies / companions / habits / commanders / country / soldiers)

24. The scene was FAMILIAR to him.

(strange / near / alarming / well-known / unknown / interesting)

25. The teacher helped him to SELECT a book.

(bind / write / read / find / illustrate / choose)

26. He is a busy man and has little LEISURE.

(enjoyment / spare time / pleasure / occupation / company / engagement)

27. The ANCIENT castle still stands.

(ruined / stone / old / medieval / royal / tall)

28. Is your servant RELIABLE?

(trustworthy / well-trained / well-paid / willing / punctual / religious)

29. This is merely an ORNAMENT.

(order / ordinary / decoration / testament / instrument / toy)

30. Do you POSSESS much money?

(earn / own / need / claim / inherit / spend)

GO STRAIGHT ON TO PAGE 4.

31. This school has EXTENSIVE playing-fields.

(distant / expensive / extra / large /magnificent / outside)

32. The dancer had very ELEGANT movements.

(swift / invisible /fascinating / awkward / intricate / graceful)

33. She tried to CONCEAL a handkerchief.

(hide / find / borrow / buy / mend / embroider)

34. They are still in an AGONY of suspense.

(appearance / attitude / torment / feeling / thrill / uncertainty)

35. I arrived PUNCTUALLY at my dentist's house.

(timidly / fearfully / late / personally / promptly / pompously)

36. A BRIEF note came by this morning's post.

(stamped / short / anonymous / tragic / bank / unexpected)

37. That is a PECULIAR thing to say.

(stupid / clever / good / particular / accurate / odd)

38. This story is INCREDIBLE.

(unbelievable / false / intelligible / true / doubtful / sensible)

39. I spoke to my COLLEAGUE about it.

(competitor / fellow-worker / parent / servant / headmaster / teacher)

40. These buildings are quite MODERN.

(recent / handsome / ancient / elaborate / concrete / luxurious)

41. They caught a glimpse of the bird's PLUMAGE.

(flight / nest / young / mate / feathers / colouring)

42. Elizabeth saw Mrs White BECKONING.

(approaching / disappearing / signalling / shopping / returning / talking)

43. I shall DEMONSTRATE how it is done.

(declare / demand / decide / show / wonder / state)

44. He fainted through sheer EXHAUSTION.

(fright / surprise / pain / rage / heat / tiredness)

45. I overheard a DIALOGUE in the train.

(catalogue / conversation / telephone / striking-clock / scream / lecture)

46. Before long the wolves had CONSUMED all the meat.

(found / resumed / stolen / plundered / devoured / contaminated)

47. One must be patient if one wishes to OBSERVE birds.

(train / photograph / snare / attract / film / watch)

GO STRAIGHT ON TO PAGE 5.

48. The soldiers were advancing CAUTIOUSLY.

(quickly / boldly / gladly / slowly / carefully / casually)

49. DELIVER us from evil.

(enliven / improve / restrain / free / delight / imprison)

50. The duchess had a BRILLIANT stone in her ring.

(valuable / cheap / artificial / bright / large / beautiful)

51. His punishment was JUST.

(mild / harsh / unfair / undeserved / nothing / fair)

52. Flying may soon be the NORMAL method of travel.

(regular / fastest / only / national / best / most dangerous)

53. The dog QUIVERED with excitement.

(snarled / howled / trembled / barked / jumped / wagged his tail)

54. In the early evening the ASSAULT began.

(fun / tempest / ceremony / programme / performance / attack)

55. The heat is INTOLERABLE.

(insufficient / impossible / unbearable / suffocating / summery / interminable)

56. I thought he stole the apples, but he is INNOCENT.

(guilty / insane / harmless / blameless / forgiven / unfair)

57. After the trial the prisoner was ACQUITTED.

(charged / suspected / congratulated / honoured / set free / detained)

58. Monkeys are very AGILE.

(treacherous / clever / cunning / mischievous / amusing / nimble)

59. The London apprentices were STAUNCH supporters of the king.

(unreliable / firm / trained / hereditary / old / former)

60. The prisoners received very MEAGRE rations.

(tasty / abundant / nourishing / scanty / inviting / tough)

61. Two SPECTATORS were injured by the bull.

(inspectors / farmers / onlookers / bull-fighters / specialists / auctioneers)

62. Even his friends FORSOOK him when he was in disgrace.

(rebuked / taunted / ridiculed / deserted / forbade / respected)

63. Did you break that DELIBERATELY?

(recently / accidentally / carelessly / honestly / intentionally / viciously)

64. What will be the RESULT of this?

(perfect / effect / insult / cause / sign / reverse)

GO STRAIGHT ON TO PAGE 6.

65. Please RETAIN your tickets for inspection.

(keep / return / punch / examine / give / tear up)

66. The escaped prisoner RESOLVED to give himself up.

(refused / was afraid / tried / dreaded / decided / hastened)

67. The REVOLT of the slaves did not help their cause.

(hatred / retreat / cruelty / idleness / punishment / rebellion)

68. The knights were always COURTEOUS.

(brave / strong / warlike / polite / untiring / obedient)

69. He stood on an ELEVATED platform.

(elongated / low / raised / broad / elaborate / celebrated)

70. It is PROBABLE that the circus will return in six months.

(unlikely / certain / unknown / known / likely / possible)

71. The king's PHYSICIANS were brought to the palace.

(musicians / acrobats / jesters / physicists / ministers / doctors)

72. The railwayman DETACHED the engine.

(derailed / stopped / attached / refuelled / unfastened / detonated)

73. The Norman noble behaved in a HAUGHTY manner.

(rude / unfair / proud / severe / foolish / angry)

74. The machine broke owing to a DEFECT in its construction.

(delay / flaw / stupidity / alteration / twist / perfection)

75. The thief ENRAGED the farmer.

(angered / attacked / disturbed / killed / stole from / escaped)

76. Try to PERSUADE them that it is true.

(permit / tell / inform / impersonate / convince / pervade)

77. That is my OPINION.

(opportunity / fault / hope / view / demand / truth)

78. His statement was not ACCURATE.

(accepted / understood / untrue / heard / correct / believed)

79. The wound inflicted was MORTAL.

(painful / dangerous / trifling / poisonous / deadly / healing)

80. In PREVIOUS years he had travelled a great deal.

(later / leap / former / peaceful / recent / prosperous)

LOOK OVER YOUR WORK UNTIL TIME IS UP.

DO NOT TURN OVER OR OPEN THIS BOOK UNTIL YOU ARE TOLD

MORAY HOUSE EXPERIMENTAL

WORD FORMATION TEST I/R.

Not to be filled in by the Scholar	
Age in years and completed months y. m.	
Page	Score
2	
3	
4	
TOTAL	
Signature of marker.	

Fill in the following particulars at once:-

1. Your Surname (In capital letters).....
2. Your Christian Name(s) (In capital letters).....
3. Sex (Boy or Girl).....
4. Name of your school.....
5. Class you are in.....
6. Your Age.....years.
7. Date of Your Birthday.....
8. Today's Date.....

In this test you have to write in the blank space the correct word formed from the word in capital letters.

Here are some examples:

EMPLOY He went everywhere looking for ....employment.....

FEED He was very hungry, so they gave him .....food.....

FULL This milk will ....fill... the jug.

CHILD She behaved in a very ....childish... manner.

Now do these. Write the word clearly and be sure to spell it correctly.

FLY The aeroplane made the ..... in record time.

ANGRY He left the room in great .....

ITALY They drank ..... wine at lunch.

LONG The ..... of the snake was three feet.

Correct your answers. They should be:- (1) Flight, (2) Anger, (3) Italian, and (4) Length.

Now read the following carefully.

1. All the questions that follow are like those you have just done.

2. When you are told to begin, turn to page 2 and start working at once.

3. Work as quickly and as carefully as you can.

4. Make any alterations in your answers clearly.

5. You will have 30 minutes. No one is expected to do everything. Just do as much as you can.

DO NOT TURN OVER UNTIL YOU ARE TOLD.

Do the questions below in the same way as those you have just done. Write in the blank space the correct word formed from the word in capital letters.

1. ACT — The soldiers went into .....
2. SUN — The day was bright and .....
3. CRUEL — He was hated for his .....
4. BRAVE — He was given a medal for his .....
5. LOYAL — He was well rewarded for his .....
6. EXPENSE — Fur coats are often .....
7. SUCCESS — Tom was pleased that he had been ..... in winning the prize.
8. GRACE — She is a very ..... dancer.
9. THOUGHTFUL — To solve the problem one must ..... hard.
10. DISTURB — A few noisy people caused a .....
11. DEEP — No one knows the ..... of this lake.
12. DANGER — This is a ..... corner for motorists.
13. SPAIN — Drake defeated the ..... fleet.
14. VARIOUS — There is a large ..... of cakes to choose from.
15. WIDE — What is the ..... of the river?
16. DECIDE — He refused to alter his .....
17. GIVE — You may have it for nothing, as a .....
18. AGREE — The partners soon came to an ..... about the division of the profits.
19. RECEIVE — The crowd gave the Prime Minister a great .....
20. PROSPER — The nation hoped for .....
21. PLEASANT — He did all he could to ..... his friend.
22. AFFECTION — Jean wrote her friend an ..... letter.
23. CHARITY — This man is always kind and .....
24. PROUD — She took ..... in keeping her house clean.
25. BRIGHT — The street lamp will ..... the pavement.
26. YOUNG — In her ..... she had played tennis.
27. WISE — Solomon was famous for his .....
28. GENEROUS — He was delighted with his uncle's .....
29. VALUABLE — Do not speak, if you ..... your life.
30. APOLOGY — He was very ..... for arriving so late.

GO STRAIGHT ON TO PAGE 3.

31. PATIENCE — Agnes was tired of waiting for her lunch; she was not a ..... child.

32. RAG — His clothes were ..... and torn.

33. MISERY — The cold, foggy weather made her .....

34. QUARREL — Why are you so .....?

35. GLORY — Old soldiers talked often of this ..... victory.

36. ECONOMY — In wartime people must ..... in many ways.

37. SATISFY — His son's success gave him .....

38. IGNORE — The poor peasants were ashamed of their .....

39. AGILE — The tennis player showed great .....

40. ENERGY — As a young man he was very .....

41. BLACK — His enemies endeavoured to ..... his reputation.

42. EASE — The problem is .....

43. COMPLAIN — The angry customer made a ..... to the manager.

44. FREE — John opened the cage and gave the bird its .....

45. WARM — I like the ..... and comfort of this room.

46. WEARY — The tramp was tired and walked ..... along the road.

47. GHOST — All at once a ..... voice was heard.

48. BEG — The old ..... knocked at the door and asked for bread.

49. TRIUMPH — The conquerors made a .....entry. into the town.

50. POOR — In some big cities there is much .....

51. POPULAR — As school captain he enjoyed great .....

52. FORTUNE — It is ..... that we have enough food with us.

53. GALLANT — Unfortunately the soldier's ..... was in vain.

54. NATURE — To guard against danger is .....

55. ABOLITION — Britain was right to ..... slavery.

56. HEROISM — He won the V.C. for his ..... deed.

57. PERIL — He journeyed through ..... seas.

58. LADEN — Do not ..... the camel too heavily.

59. CERTAIN — I cannot tell you with any .....

60. JUST — "I demand .....," shouted the prisoner.

61. SPEAK — The chairman delivered a brilliant .....

62. SAFE — The refugees reached Switzerland in .....

63. STRONG — He had the ..... of a Hercules.

64. DISOBEDIENT — The boys were punished for their .....

65. MAINTENANCE — It costs huge sums to ..... the army.

GO STRAIGHT ON TO PAGE 4.

66. REVELATION The prisoner would not ..... any secrets.

67. ENDURE The runners in the long distance race showed much .....

68. RECOGNITION He failed to ..... his long-lost son.

69. FAMOUS The ..... of his mighty deeds spread far and wide.

70. ACCIDENT All the onlookers agreed that the collision was purely .....

71. ENVY Harry was very ..... of Robert's bicycle.

72. BEAUTIFUL The children brought flowers to ..... the schoolroom.

73. PURE Drinking water should be tested for its .....

74. ABLE At an early age she showed great musical .....

75. HIGH What is the ..... of this tree?

76. PUBLIC The newspapers gave the story great.....

77. FROST I expect the pond will ..... tonight.

78. DISHONEST Because of his ..... he lost his job.

79. DENMARK ..... butter is delicious.

80. FAIL His attempt to climb Mount Everest was a .....

LOOK OVER YOUR WORK UNTIL TIME IS UP.

DO NOT TURN OVER OR OPEN THIS BOOK UNTIL YOU ARE TOLD

M O R A Y H O U S E E X P E R I M E N T A L

VERBAL ANALOGIES TEST I/R

Not to be filled in by the Scholar	
Age in years and completed months y. m.	
Page	Score
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TOTAL	
Signature of marker.	

Fill in the following particulars at once:-

1. Your Surname (In capital letters).....
2. Your Christian Name(s) (In capital letters).....
3. Sex (Boy or Girl).....
4. Name of your school.....
5. Class you are in.....
6. Your Age.....years.
7. Date of Your Birthday.....
8. Today's Date.....

Look at this example:-

Apple is to Fruit as (cabbage / robin / sheep) is to (fish / vegetable / insect)

"Cabbage" is underlined in one set of brackets and "vegetable" in the other set, because just as an apple is a fruit so a cabbage is a vegetable.

Here is another example:-

Kitten is to Cat as (calf / puppy / lamb) is to (horse / lion / dog)

"Puppy" and "dog" are underlined because just as a kitten is a young cat so a puppy is a young dog.

Now do these. In each question underline TWO words, one in each set of brackets.

(1) Chalk is to Blackboard as (draw / duster / pencil) is to (rubber / paper / clean)

(2) July is to Summer as (December / month / warm) is to (Christmas / cold / winter)

(3) Hand is to Glove as (arm / foot / head) is to (boot / body / toe)

Correct your answers. You should have underlined the words:-
(1) pencil, paper (2) December, winter (3) foot, boot.

Now read the following carefully.

1. All the questions that follow are like those you have just done.

2. When you are told to begin, turn to page 2 and start working at once.

3. Work as quickly and as carefully as you can.

4. Make any alterations in your answers clearly.

5. You will have 25 minutes. No one is expected to do everything. Just do as much as you can.

DO NOT TURN OVER UNTIL YOU ARE TOLD.

In each of the following questions underline TWO answers, one in each set of brackets.

. Sponge is to Wash as (towel / soap / rough) is to (wet / dry / rinse)

. Fur is to Squirrel as (silk / nut / feather) is to (velvet / sheep / bird)

. Stone is to Quarry as (fire / coal / soot) is to (black / burn / mine)

. Book is to Title as (man / pencil / reading) is to (paper / name / woman)

. Knife is to Cut as (nail / toothbrush / pin) is to (slash / prick / sew)

. Spring is to Winter as (youth / summer / snow) is to (morning / flowers / old age)

. Bunch is to Grapes as (decorations / garden / bouquet) is to (flowers / plums / wine)

. Blossom is to Spring as (tree / fruit / pick) is to (autumn / sweet / winter)

. Crow is to Black as (canary / mauve / cage) is to (sing / yellow / parrot)

. Lemon is to Sour as (bread / honey / bee) is to (crumbs / sweet / sugar)

. Ruler is to Length as (scales / ounces / grocers) are to (weight / height / size)

. Scissors are to Cloth as (saw / shovel / pin) is to (coal / stone / wood)

. Minus is to Subtract as (cross / plus / problem) is to (divide / arithmetic / add)

. Cat is to Mouse as (dog / rat / wolf) is to (leopard / lamb / flea)

. Man is to Skin as (petal / seed / tree) is to (leaves / blossom / bark)

. Farthing is to Penny as (sixpence / half a crown / money) is to (pound / shilling / florin)

. Orange is to Fruit as (milk / carrot / sugar) is to (tea / pudding / vegetable)

. Old is to Young as (clean / happy / strong) is to (weak / tears / beautiful)

. Mary is to She as (John / him / we) is to (he / Anne / her)

. Bird is to Chirp as (horse / cow / cat) is to (bark / bray / neigh)

. Short is to Tall as (dwarf / enormous / fairy) is to (warrior / giant / knight)

. Commence is to Begin as (cease / continue / fail) is to (stop / succeed / start)

. Milk is to White as (cow / grass / cocoa) is to (buttercups / clover / green)

. House is to Room as (sea / ship / cottage) is to (sailor / cabin / float)

. Feather is to Bird as (silk / cotton / wool) is to (mouse / sheep / elephant)

. Horse is to Stable as (pig / cow / sheep) is to (farm / calf / sty)

. Sailor is to Ship as (liner / captain / nurse) is to (hospital / doctor / medicine)

. Apple is to Greengrocer as (raisins / handkerchief / knife) is to (draper / shop / fruit)

. Cunning is to Fox as (sly / horrid / stubborn) is to (dog / mouse / mule)

. Fish is to Sea as (man / bird / star) is to (trains / air / night)

. Minute is to Time as (ounce / foot / gallon) is to (length / area / pound)

. Mutton is to Sheep as (grass / pork / kidney) is to (lamb / cow / pig)

GO STRAIGHT ON TO PAGE 3.

Bullet is to Gun as (stone / warrior / arrow) is to (sling / pistol / spear)

Rook is to Caw as (fish / frog / spawn) is to (croak / marsh / bellow)

Board is to Floor as (slate / brick / grey) is to (garden / roof / road)

Nephew is to Niece as (uncle / boy /son) is to (lady / daughter / mother)

Screw is to Screwdriver as (joiner / nail / wood) is to (hammer / saw / tack)

Easter is to Spring as (weekday / Christmas / holly) is to (holiday / winter / sports)

More is to Add as (less / number / plus) is to (divide / multiply / subtract)

Bird is to Hop as (frog / snail / mouse) is to (leap / fly / pond)

Water is to Thirst as (liquid / drought / food) is to (hunger / solid / poverty)

Song is to Sing as (poem / book / poet) is to (recite / verse / talk)

Pig is to Litter as (sheep / bee / hen) is to (wool / brood / buzz)

Cattle is to Herd as (dogs / sheep / pigs) is to (fold / flock / shepherd)

Accept is to Refuse as (invite / perhaps / yes) is to (please / no / welcome)

Have is to Had as (am / see / went) is to (gone / saw / are)

Summer is to Winter as (spring / day / sun) is to (night / morning / December)

Trunk is to Elephant as (paw / tail / beak) is to (dog / bird / mouse)

Two is to Second as (one / three / four) is to (next / once / third)

Beginning is to End as (birth / marriage / mother) is to (start / death / boy)

Ceiling is to Room as (chimney / fireplace / roof) is to (kitchen / garden / House)

Subtract is to Add as (minus / divide / sum) is to (arithmetic / equal / plus)

A is to Beginning as (B / start / Z) is to (end / Y / century)

Castle is to Tower as (church / moat / turret) is to (priest / steeple / pulpit)

Bracelet is to Wrist as (ring / necklace / brooch) is to (jewel / ear / finger)

Orange is to Skin as (plum / apple / egg) is to (stone / shell / core)

Good is to Bad as (true / clever / polite) is to (evil / sad / rude)

Father is to Uncle as (nephew / mother / son) is to (niece / daughter / aunt)

AC is to BD as (GH / EF / EG) is to (FH / FG /GI)

Large is to Larger as (good / little / many) is to (bad / better / worse)

Pond is to Lake as (fish / stream / oar) is to (boat / river / water)

Brother is to Sister as (uncle / husband / nephew) is to (mother / niece / cousin)

March is to April as (Sunday / Tuesday / Wednesday) is to (Thursday / Friday / Saturday)

Ink is to Pen as (chalk / paint / paper) is to (white / pencil / brush)

Knee is to Leg as (wrist / elbow / toe) is to (heel / finger / arm)

GO STRAIGHT ON TO PAGE 4.

66. Breakfast is to Morning as (meal / supper / night) is to (evening / tea / food)

67. Copper is to Penny as (silver / gold / shilling) is to (money / sixpence / farthing)

68. Finger is to Hand as (ankle / heel / toe) is to (leg / shoe / foot)

69. Long is to Short as (fat / heavy / strong) is to (light / small / low)

70. A is to B as (P / E / X) is to (D / Q / Z)

71. Liquid is to Water as (milk / solid / drink) is to (stone / wet / heavy)

72. King is to Queen as (prince / duke / countess) is to (duchess / earl / lady)

73. Big is to Small as (tall / heavy / fast) is to (thin / slow / weak)

74. Boy is to Son as (brother / girl / fast) is to (sister / daughter / wife)

75. See is to Blind as (smell / hear / noise) is to (deaf / silent / dumb)

76. Quick is to Speed as (heavy / small / hot) is to (weight / length / light)

77. North is to South as (east / north-east / west) is to (north-east / south-east / south-west)

78. 2 is to II as (3 / 1 / 4) is to (V / VI / III)

79. BC is to AD as (NR / QR / PQ) is to (MS / OR / MR)

80. Am is to Was as (will be / have / were) is to (been / went / had)

LOOK OVER YOUR WORK UNTIL TIME IS UP.

DO NOT TURN OVER OR OPEN THIS BOOK UNTIL YOU ARE TOLD.

MORAY HOUSE EXPERIMENTAL

NUMBER AND LETTER SERIES TEST I/R.

Not to be filled in by the Scholar.	
Age in years and completed months y. m.	
Page	Score
2	
3	
TOTAL	
Signature of marker:	

Fill in the following particulars at once:-

1. Your Surname (In capital letters).....
2. Your Christian Name(s) (In capital letters).....
3. Sex (Boy or Girl).....
4. Name of your school.....
5. Class you are in.....
6. Your Age.....years.
7. Date of Your Birthday.....
8. Today's Date.....

The alphabet is printed here to help you with the questions below.

A B C D E F G H I J K L M N O P Q R S T U V W X Y Z

Look at these letters:-

..... D F H J .....

F is the second letter in the alphabet after D, H is the second letter after F, and J is the second letter after H. In the blank space at the beginning, therefore, we must write B, and in the blank space at the end we must write L. Thus:-

....B..... D F H J.....L....

Now look at these numbers:-

..... 5, 8, 11, 14.....

Each number is three more than the number before it. In the blank space at the beginning, therefore, we write 2, so that 5 is 3 more than 2; and in the blank space at the end we write 17, which is 3 more than 14. Thus:-

....2..... 5, 8, 11, 14....17....

In the same way, in each of the questions below there is a rule which tells us how one letter, or number, is found from those coming before or after it. You have to find out what the rule is, and then write in each of the two blank spaces what should go there.

See if you can write the correct letter, or number, in each of the blank spaces below:-

(1) .....B X C X D X,.....

(2) .....4, 6, 8, 10,.....

Correct your answers. In the first question, you should have written X at the beginning and E at the end. In the second question, you should have written 2 at the beginning and 12 at the end.

Now read the following carefully.

1. All the questions that follow are like those you have just done.

2. When you are told to begin, turn to page 2 and start working at once.

3. Work as quickly and as carefully as you can.

4. Make any alterations in your answers clearly.

5. You will have 30 minutes. No one is expected to do everything. Just do as much as you can.

DO NOT TURN OVER UNTIL YOU ARE TOLD.

Do the questions below in the same way as those you have just done. Write <u>one</u> letter, or number, at the beginning of each line and one at the end.

The alphabet is printed here to help you.

A B C D E F G H I J K L M N O P Q R S T U V W X Y Z

1. ..... T U X T U X T .....
2. ..... 6, I0, I4, I8, ...
3. ..... L M A N O A P Q A .....
4. ..... 8, 8, 6, 6, 4, ...
5. ..... C C D E F F G H I I J .....
6. ..... 4, 8, I6, 32, ...
7. ..... C E G I .....
8. ..... 7, 0, 6, 0, 5, 0, ...
9. ..... C D E E F G G H I I .....
10. ..... 9, 8, 7, 7, 6, 5, 5, 4, 3, ...
11. ..... K N Q T .....
12. ..... 2, 0, 3, I, 4, 0, 5, I, 6, 0, ...
13. ..... L L M M N O O P P Q R R S S T .....
14. ..... I3, I0, 7, 4, ...
15. ..... P Q Q Q R S S S T U U U .....
16. ..... 5, 7, 7, 9, 9, ...
17. ..... L M N A B C O P Q A B C .....
18. ..... 2, $3\frac{1}{2}$, 5, $6\frac{1}{2}$, ...
19. ..... L K J I .....
20. ..... 80, 40, 20, I0, ...

GO STRAIGHT ON TO PAGE 3.

A B C D E F G H I J K L M N O P Q R S T U V W X Y Z

31. ..... A B D A B E A B F .....

32. ..... $I\frac{3}{4}$, $I\frac{1}{2}$, $I\frac{1}{4}$, I, ...

33. ..... Q O M K .....

34. ..... I, 3, 4, I, 4, 5, I, 5, 6, I, ...

35. ..... E F G I J K M N O .....

36. ..... 8, 2, 7, 3, 6, 4, 5, ...

37. ..... H I K L N O .....

38. ..... $\frac{3}{4}$, $\frac{5}{6}$, $\frac{7}{8}$, $\frac{9}{10}$, ...

39. ..... V S P M .....

30. ..... 3, 2, 4, 3, 5, 4, ...

31. ..... F F H H J .....

32. ..... 8, 7, 9, 8, 10, 9, 11, ...

33. ..... X B C X D E F X G H I J .....

34. ..... 7, 9, 12, 16, 21, ...

35. ..... U Q M I .....

36. ..... I, 5, 3, 7, 5, 9, 7, 11, ...

37. ..... A B P Q C D R S T S .....

38. ..... 3, 7, 5, 3, 7, 5, 3, ...

39. ..... P O P Q R Q R S T S .....

40. ..... 9, 10, 8, 9, 7, 8, ...

41. ..... C X D W E V .....

42. ..... 3, 4, 5, 2, 3, 4, 6, 2, 3, 4, 7, 2, 3, 4, ...

43. ..... L M K N J O .....

44. ..... $5\frac{2}{3}$, $4\frac{3}{4}$, $3\frac{4}{5}$, ...

LOOK OVER YOUR WORK UNTIL TIME IS UP.

DO NOT TURN OVER OR OPEN THIS BOOK UNTIL YOU ARE TOLD

MORAY HOUSE EXPERIMENTAL

WORD SERIES TEST 1/R

Not to be filled in by the Scholar	
Age in years and completed months y. m.	
Page	Score
2	
3	
4	
TOTAL	
Signature of marker.	

Fill in the following particulars at once:-

1. Your Surname (In capital letters).....
2. Your Christian Name(s) (In capital letters).....
3. Sex (Boy or Girl).....
4. Name of your school.....
5. Class you are in.....
6. Your Age.....Years.
7. Date of Your Birthday.....
8. Today's Date.....

In this test you have to think what the best order of the things mentioned would be, and then underline the FIRST and LAST of the new order.

Example 1. Shilling / penny / pound / half a crown / sixpence

Putting these in order of value we have: "penny, sixpence, shilling, half a crown, pound." The first and last words in our new order are "penny" and "pound," so we have underlined them above.

Example 2. Brown / yellow / white / cream

We have underlined "Brown" and "white" because brown is the darkest colour and white is the lightest.

Now do these. Underline the FIRST and the LAST of the new order, that is, TWO things in each question.

1. C / E / D / B / A

2. County / village / city / town

Correct your answers. You should have underlined "A" and "E" in the first questions; "County" and "village" in the second.

Now read the following carefully.

1. All the questions that follow are like those you have just done.

2. When you are told to begin, turn to page 2 and start working at once.

3. Work as quickly and as carefully as you can.

4. Make any alterations in your answers clearly.

5. You will have 20 minutes. No one is expected to do everything. Just do as much as you can.

DO NOT TURN OVER UNTIL YOU ARE TOLD.

Do the questions below in the same way as those you have just done. Underline the FIRST and the LAST of the new order, that is, TWO things in each question.

1. Cellar / ground floor / attic / first floor
2. tea / supper / lunch / breakfast
3. Egg cup / tea cup / thimble / jug / bucket
4. Cat / elephant / fly / mouse / donkey / sheep
5. Middle finger / thumb / forefinger / little finger
6. Thousand / billion / hundred / million / ten
7. First / sixth / fourth / seventh / third
8. Thursday / Friday / Tuesday / Monday / Wednesday
9. Snail / train / bicycle / rabbit
10. Week / month / century / year / fortnight
11. Shoulder / wrist / palm / finger / elbow
12. Sea / pond / lake / ocean / puddle
13. Trunk / hand-bag / suit-case / purse
14. All / few / none / many
15. duck / pigeon / ostrich / sparrow / goose
16. Ounce / hundredweight / pound / ton / stone
17. Clever / dull / brilliant / ordinary
18. Birth / old age / death / youth / childhood
19. Mouse / horse / sheep / ant / dog
20. 10 / 21 / 12 / 22 / 20 / 11
21. One / a quarter / nought / a half / three-quarters
22. Cottage / hut / palace / house
23. AB / ABCD / A / ABC / ABCDE
24. 6317 / 3716 / 6713 / 1367 / 7361
25. PQ / AB / LM / FG / XY
26. Yesterday / today / tonight / last night / tomorrow
27. Hot / boiling / cold / warm / freezing.
28. Slow / half-speed / stop / dead-slow / full-speed-ahead
29. AX / AV / AY / AZ / AW
30. Pint / quart / half-pint / gallon / half-gallon
31. Youth / infant / old man / adult
32. March 23rd / May 28th / March 10th / April 4th / May 17th.

GO STRAIGHT ON TO PAGE 43

Paragraph / sentence / word / line / chapter

Large / tiny / huge / small

Pair / score / dozen / century

Afternoon / dawn / noon / morning / sunset

5 pounds / ½ stone / 13 ounces / ½ pound / 7 ounces

Pony / horse / dog / kitten / pig

50 / 3½ score / 4 dozen / 60 / 1½ dozen

Leaf / branch / twig / tree

Good / excellent / bad / moderate

Twenty-first / twenty-sixth / seventeenth / third / fifth

Cod / whale / herring / shark / minnow

tug / canoe / liner / yacht

Seed / apple / coconut / acorn

Grandfather / son / father / grandson

Gale / breeze / typhoon / wind / calm

Pencil / match / walking-stick / pole

P / X / J / L / U

Inch / foot / half an inch / yard / half a yard / half a foot.

Shoe / skirt / blouse / hat / stocking

50 minutes / 2 hours / 25 minutes / half an hour / 100 minutes

Prince / king / earl / duke / commoner

Year / century / month / decade / week

Overcoat / shirt / jacket / waistcoat / undervest

More / least / much / little / most

Nose / ankle / waist / forehead / knee

1297 / 9127 / 1279 / 2197 / 9217

May 1941 / October 1943 / July 1942 / March 1943 / January 1941

Thigh / ankle / knee / toe / calf

RS / CD / WX / NO / GH

132 / 312 / 213 / 321 / 231 / 123

Walk / stroll / run / trot / stand

East / north-east / north / south / south-east

This week / last week / the week after next / next week / the week before last

7246 / 4726 / 7642 / 6247 / 2674 / 2467

GO STRAIGHT ON TO PAGE 4.

67. Fortnight / hour / week / day / month

68. Cherry / grape-fruit / orange / melon / plum

69. Often / seldom / never / always / sometimes

70. String / thread / rope / cord / cable

71. lm / fg / ab / pq / uv

72. 70 minutes / $1\frac{3}{4}$ hours / 35 minutes / half an hour / 90 minutes

73. 11 p.m. / 2 p.m. / 8 a.m. / 11 a.m. / 8 p.m.

74. ABcd / ABCD / Abcd / abcd / ABCd

75. Cork / air / glass / wood / lead

76. One / one and a half / a half / two / half of two and a half

77. Butterfly / flea / wasp / bird / bee

78. Tennis ball / ping-pong ball / marble / football / golf ball

79. 4321 / 4123 / 2314 / 341 / 4231

80. $\frac{6}{7}$ / $\frac{3}{4}$ / $\frac{4}{5}$ / $\frac{2}{3}$ / $\frac{5}{6}$

LOOK OVER YOUR WORK UNTIL TIME IS UP.

DO NOT OPEN THIS BOOK UNTIL YOU ARE TOLD TO DO SO

A SCALE OF
NON-VERBAL MENTAL ABILITY

(Time: 30 minutes)

Prepared by

J. W. JENKINS, M.Sc., Ph.D.

SURNAME ..... CHRISTIAN NAME(S) .....

Age ..... years ..... months

School .....

Today's Date .....

Read the following carefully.

In this book there are some sets of puzzles. Do them as well as you possibly can.

You may not have time to do them all, but every five minutes you will be told to stop and go on to the next page.

You need not ask any questions because in each set you are told what to do.

Most of the puzzles are easy, but a few are quite hard.

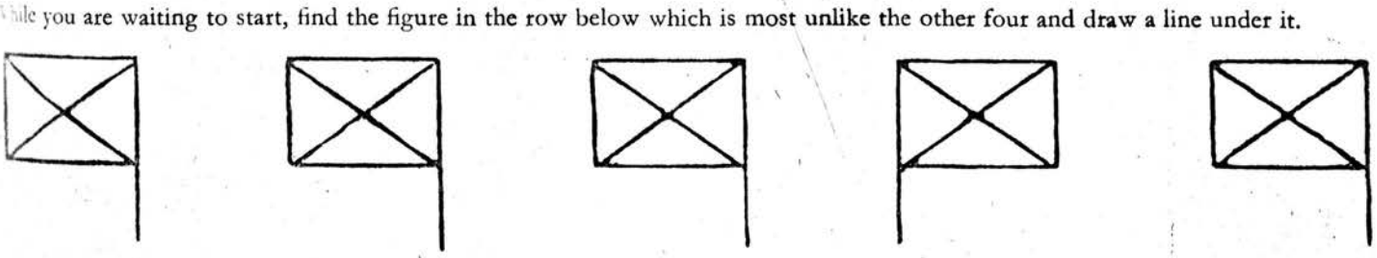
Work steadily on without wasting any time.

Be sure to stop whenever you are told.

If you alter any of your answers, do so *clearly*.

SCORE	
I ...	
II ...	
III ...	
IV ...	
V ...	
TOTAL ...	
Standardised Score ...	

While you are waiting to start, find the figure in the row below which is most unlike the other four and draw a line under it.



Do not ask any questions

DO NOT OPEN THIS BOOK UNTIL YOU ARE TOLD TO DO SO.

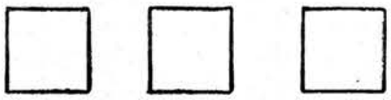
THE NATIONAL FOUNDATION FOR EDUCATIONAL RESEARCH IN ENGLAND AND WALES.

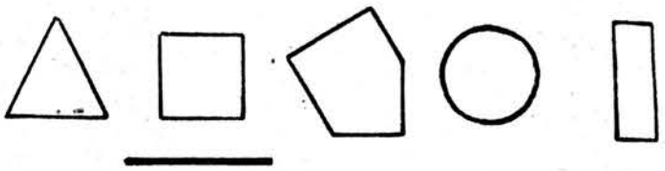
.....

Today's Date .....

On the left of each of the rows below there are three figures which are alike. On the right there are five more figures. Find which ONE of these is most like the three figures on the left and draw a line under it. (The first one has been done for you.)

Ex.





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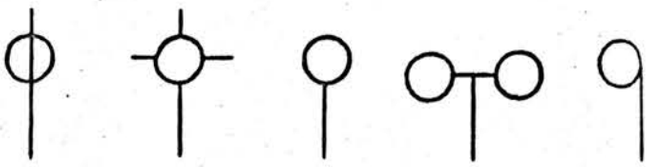

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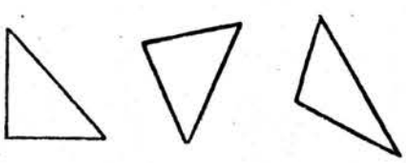

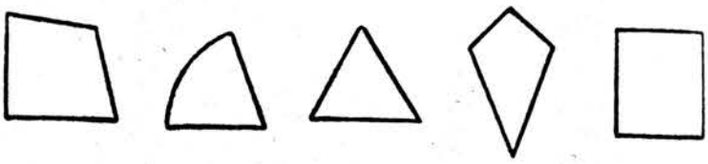

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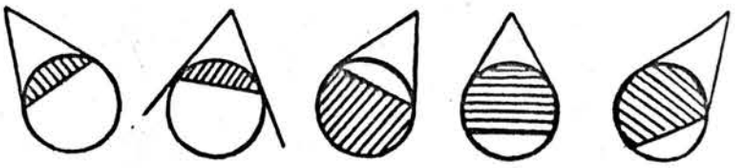
5

6



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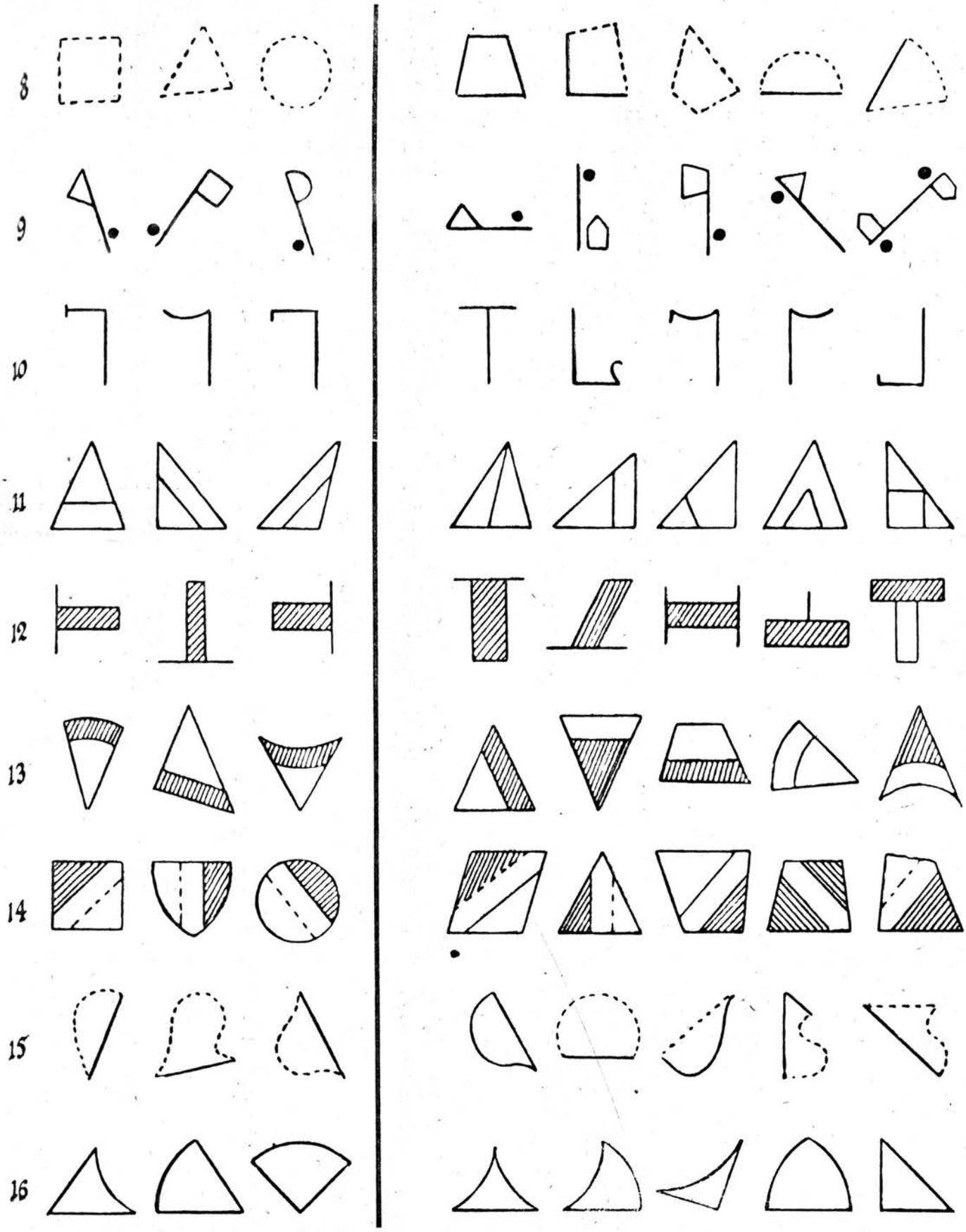
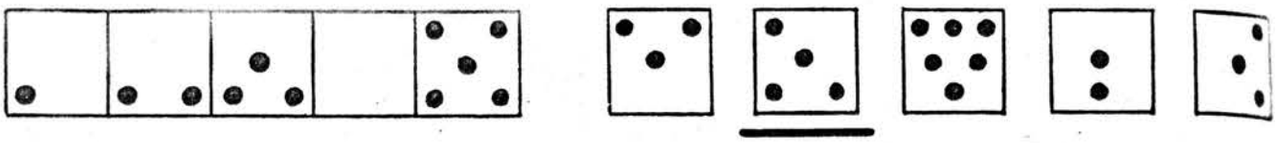


Do not turn over until you are told to do so.

8. Today's Date.....

To the left in each of the lines below there are five squares arranged in order. ONE of these squares has been left empty. Find which one of the five squares on the right should take the place of the empty square and draw a line under it. (The first one has been done for you.)

Ex.



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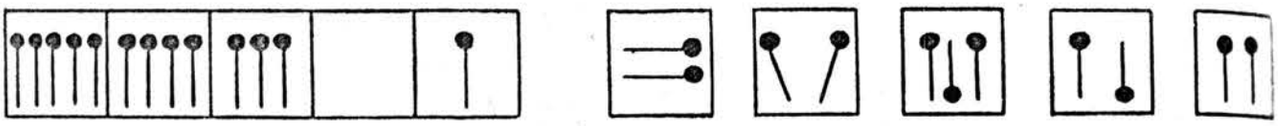

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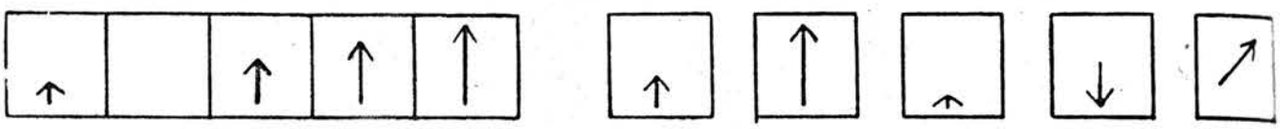

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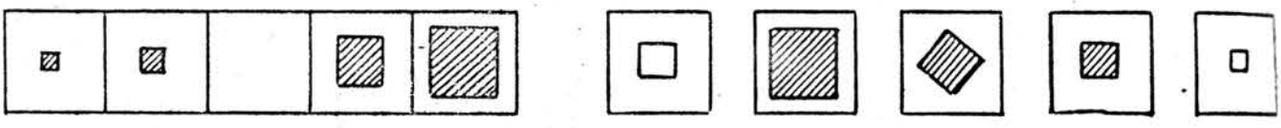

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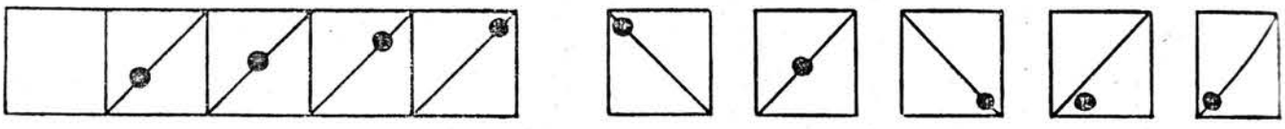

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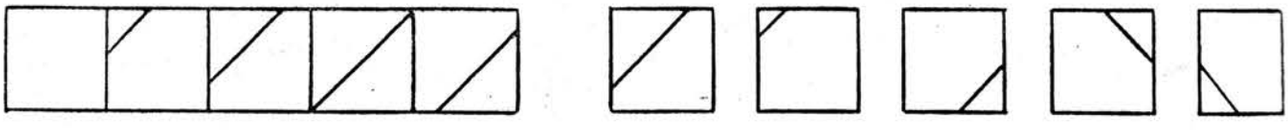

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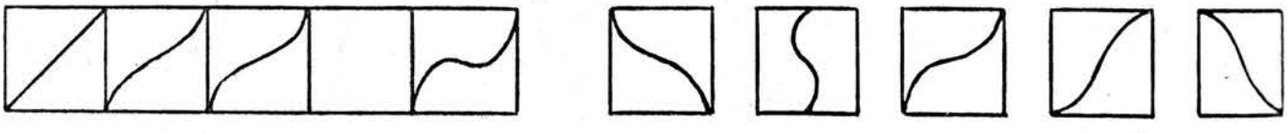

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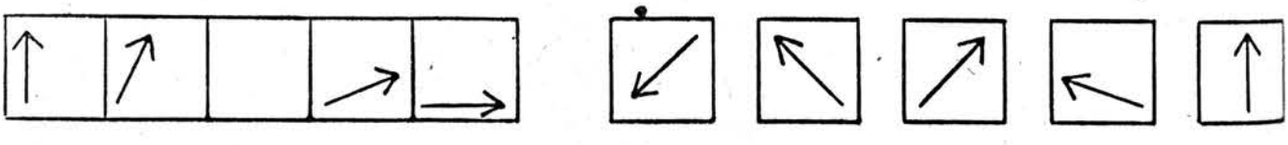

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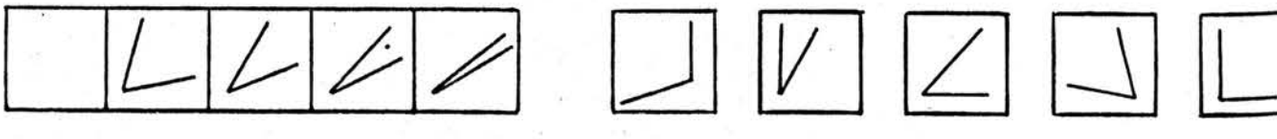
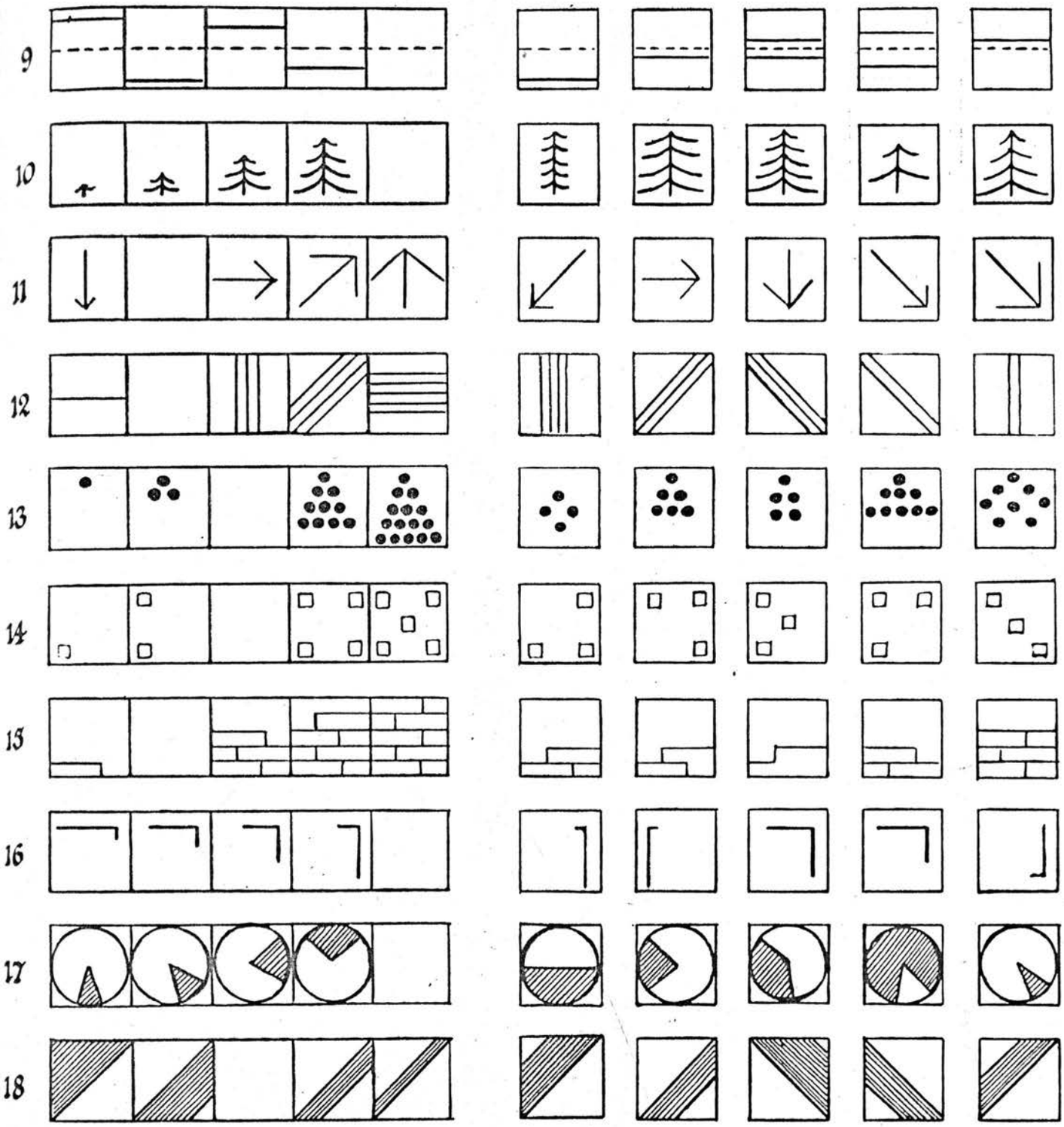


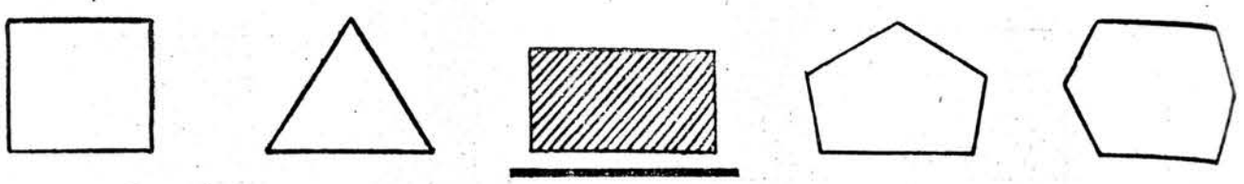
Go straight on to the next part.

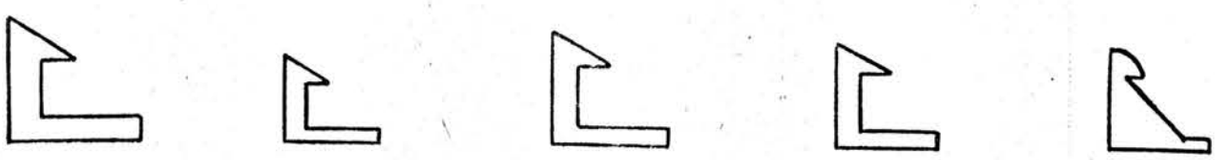


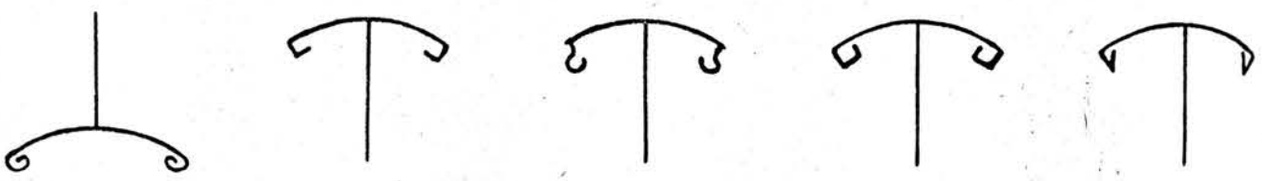
Do not turn over until you are told to do so.

8. Today's Date.....

In each of the rows below there are five figures. Find ONE figure in each row which is most unlike the other four and draw a line under it. (The first one has been done for you.)

Ex. 

1 

2 

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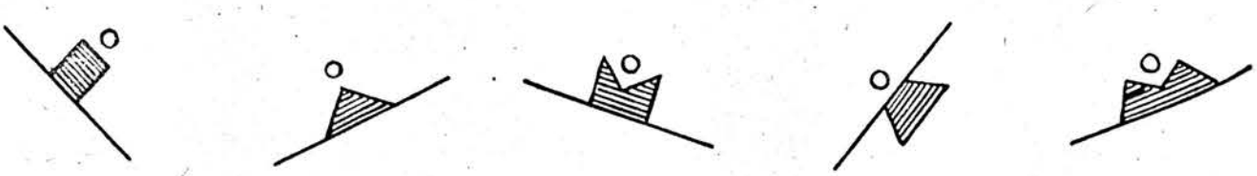
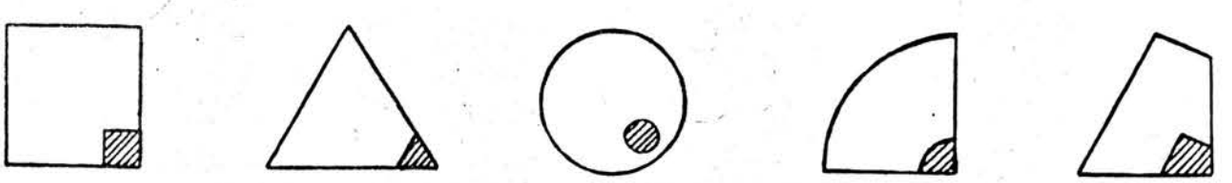
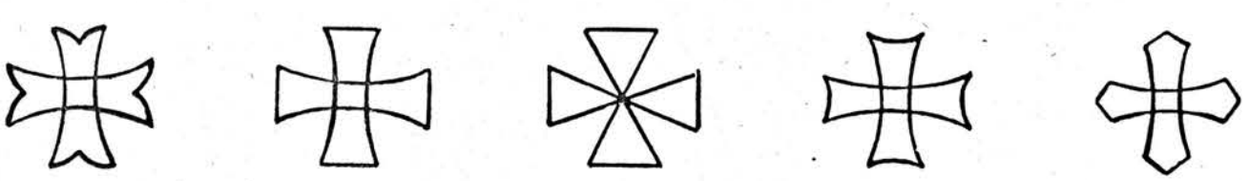
4 

5 

6 

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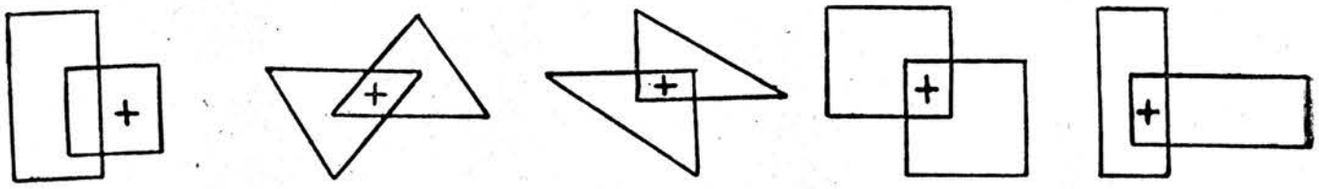
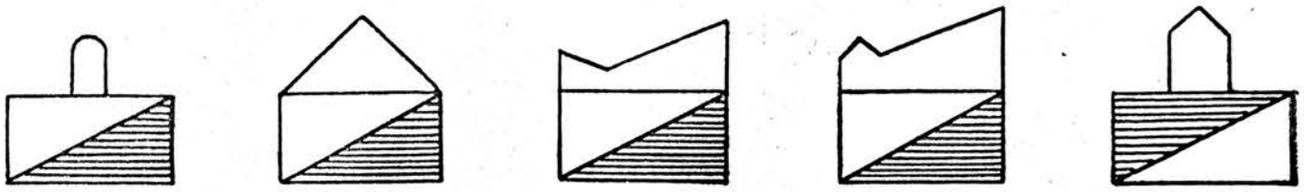
8 

9 

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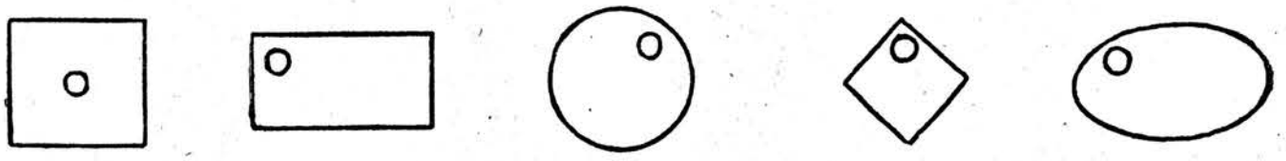
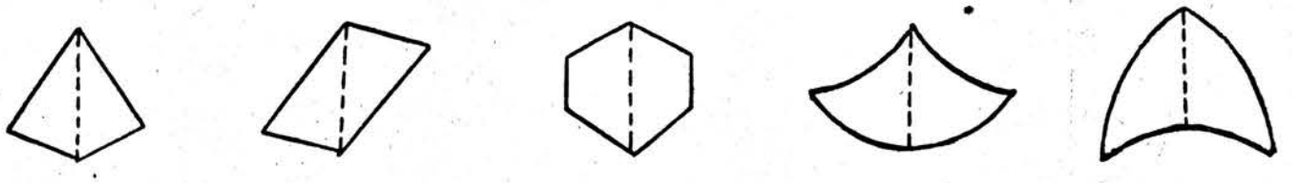
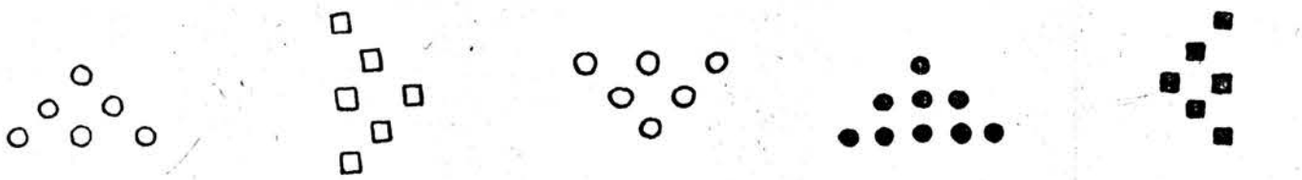
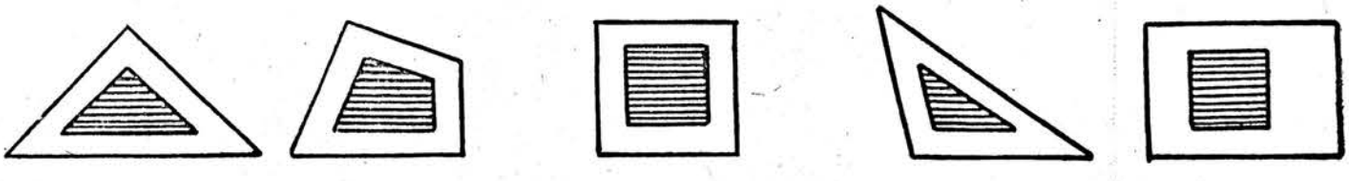
11 

12 

13 

14 

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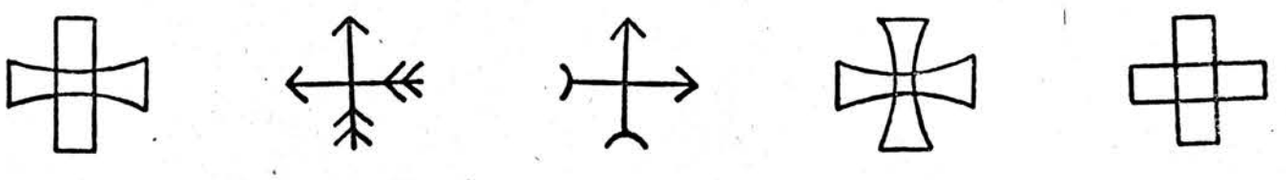
16 

Do not turn over until you are told to do so.

9. Today's Date.....

Each of the sets of figures below can be arranged in order. Think of each set arranged in order and draw a line under the ONE which comes in the middle. (The first one has been done for you.)

Ex.

1

2

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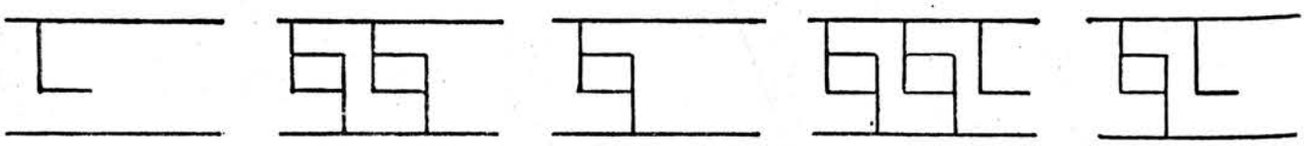

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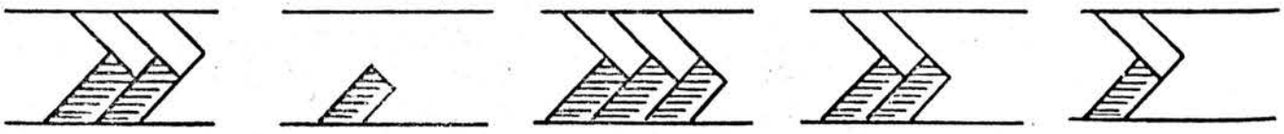

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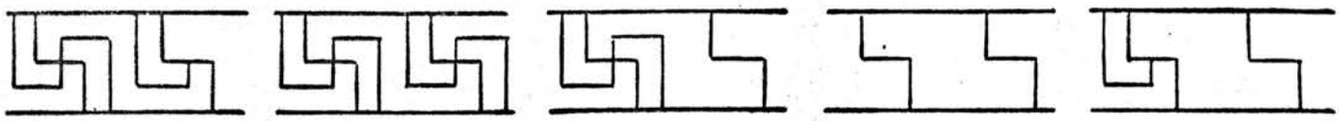
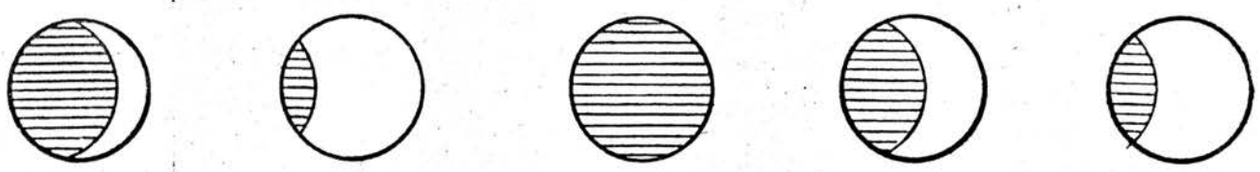
8 

9 

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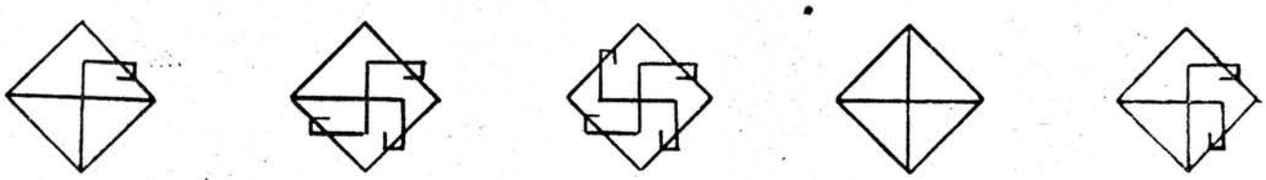
11 

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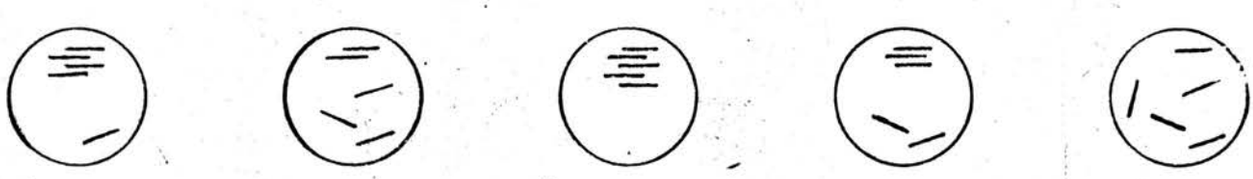
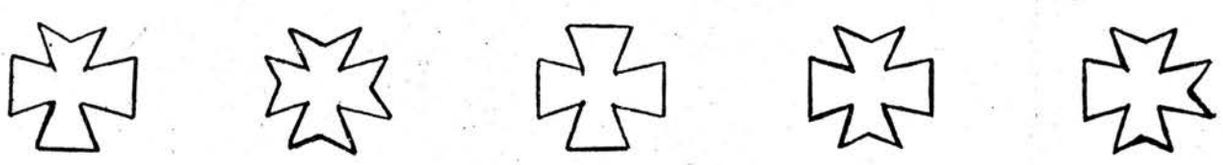
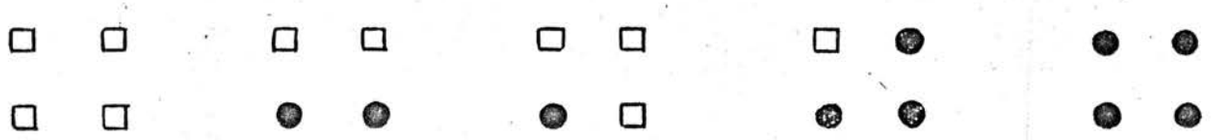
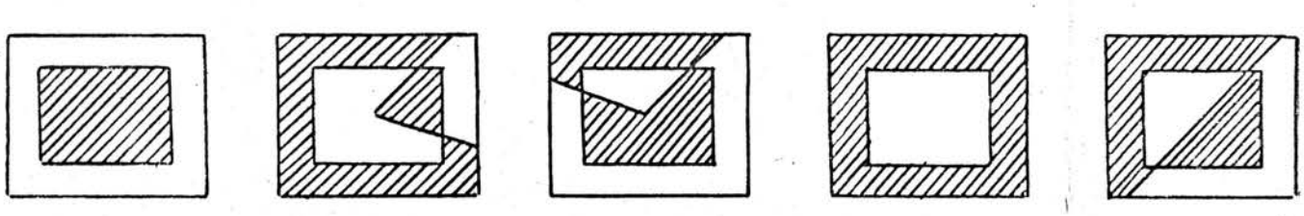
13 

14 

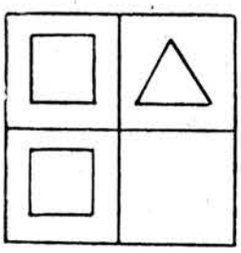
15 

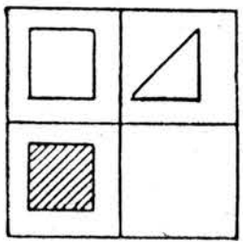
16 

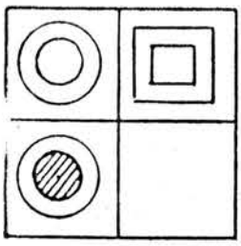
Do not turn over until you are told to do so.

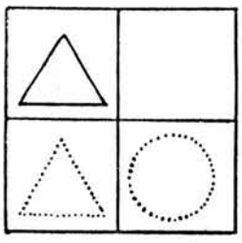
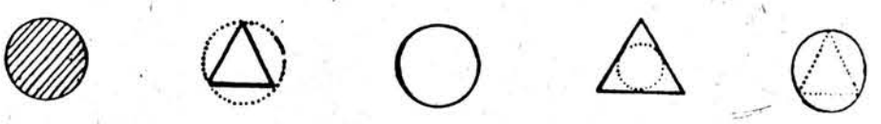
8. Today's Date.....

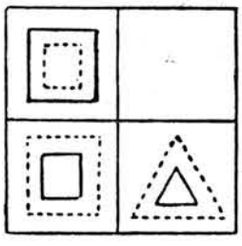
In the big square on the left of each line below, one of the four small squares has been left empty. ONE of the five figures to the right should fill the empty square. Find this figure and draw a line under it. (The first one has been done for you.)

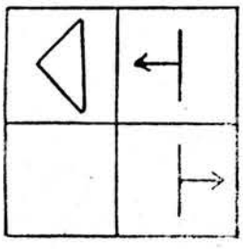
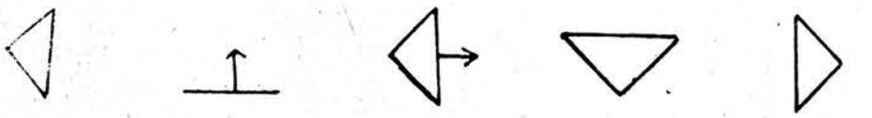
Ex. 


1 

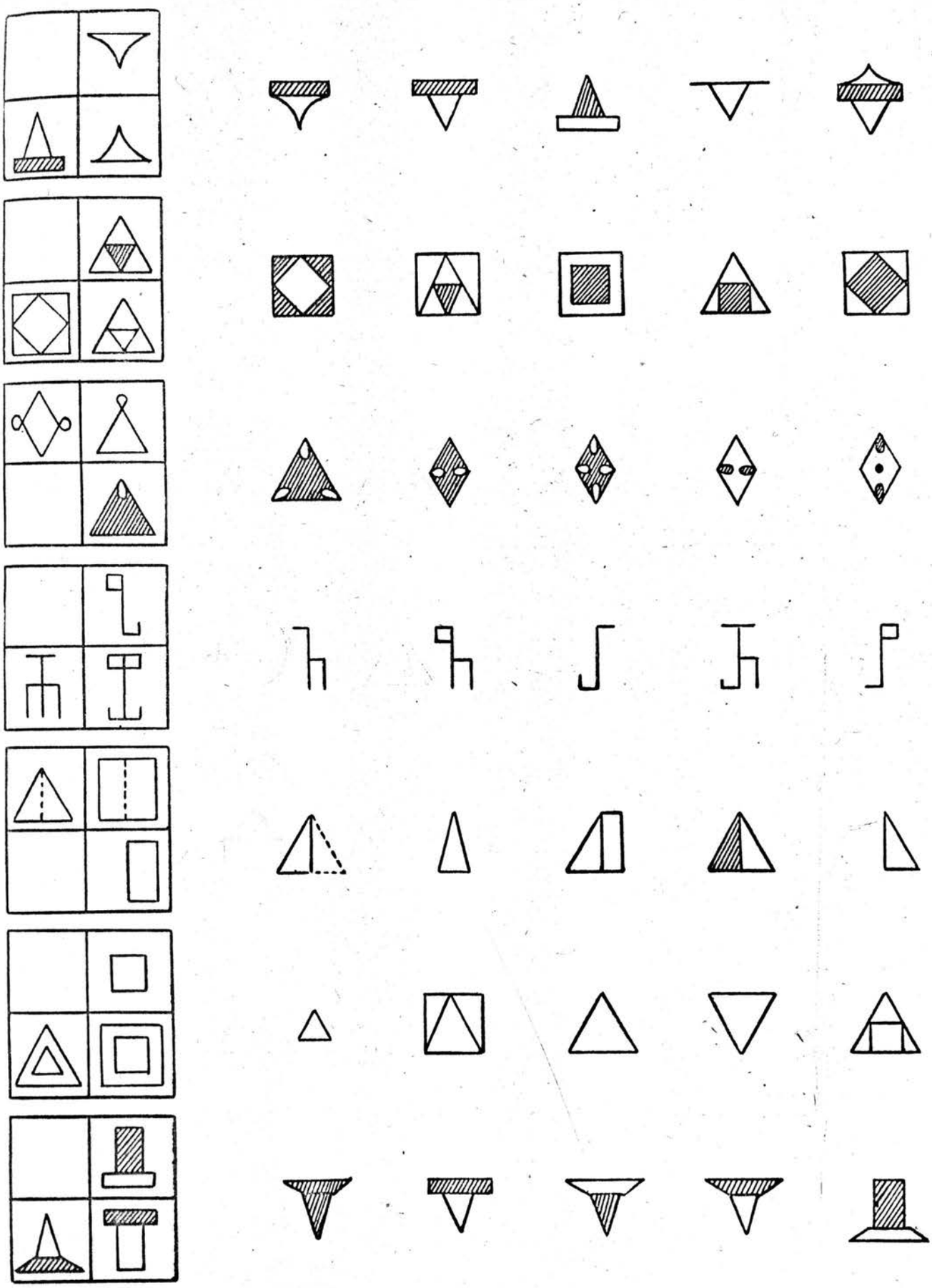

2 


3 


4 


5 


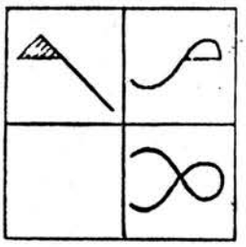
Go straight on to the next page.



Turn over and go straight on.

8. Today's Date.....

13



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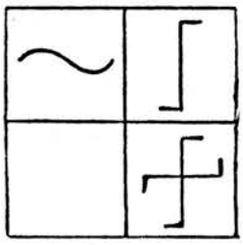

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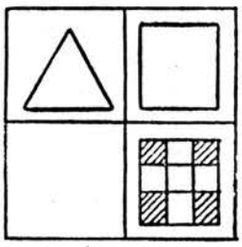

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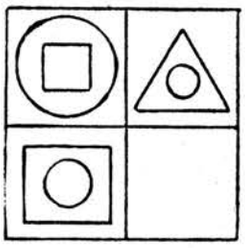

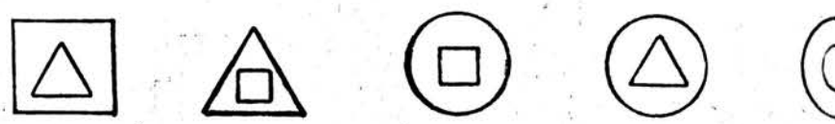

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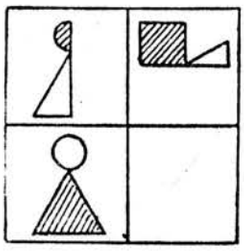

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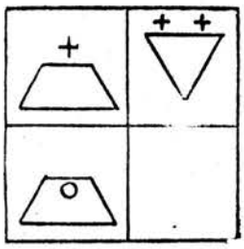

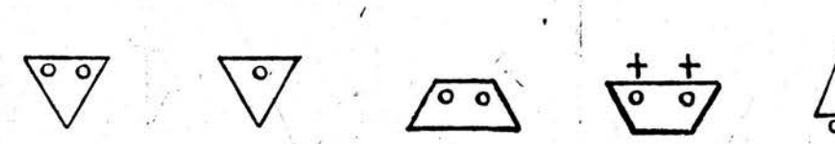

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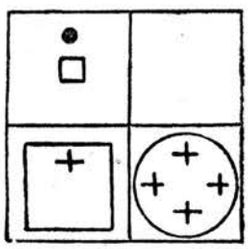


Brighton Herald Ltd.—8859 1

DO NOT TURN OVER OR OPEN THIS BOOK UNTIL YOU ARE TOLD.

MORAY HOUSE EXPERIMENTAL

MECHANICAL ARITHMETIC TEST I/R

Not to be filled in by the Scholar	
Age in years and completed months. y. m.	
Page	Score
2	
3	
4	
5	
TOTAL	
Signature of marker.	

Fill in the following particulars at once:-

1. Your Surname (In capital letters).....
2. Your Christian Name(s) (In capital letters).....
3. Sex (Boy or Girl).....
4. Name of your school.....
5. Class you are in.....
6. Your Age.....years.
7. Date of Your Birthday.....
8. Today's Date.....

Here are some examples of the sums you have to do in this test. Look at the top of each sum, see whether it says add, subtract, multiply, or divide, and then find the answer.

1. ADD	2. SUBTRACT	3. MULTIPLY	4. DIVIDE
32 15 47	786 263	538 4	963 by 3

Correct your answers. You should have:- (1) 94. (2) 523.

(3) 2152. (4) 321.

Now read the following carefully:-

1. All the questions that follow are like those you have just done.
2. When you are told to begin, turn to page 2 and start working at once.
3. Work as quickly and as carefully as you can.
4. Make any alterations in your answers clearly.
5. You may work the sums in your head, or you may do your working on the page if you wish to do so.
6. You will have 45 minutes. No one is expected to do everything. Just do as much as you can.

DO NOT TURN OVER UNTIL YOU ARE TOLD.

Be careful to look at the top of each question to see whether it says add, subtract, multiply or divide.

1. ADD	2. SUBTRACT	3. MULTIPLY	4. DIVIDE
68 49 35 87	8527 4293	538 4	8164 by 4

5. ADD	6. ADD	7. SUBTRACT	8. SUBTRACT
36 57 84 44	28 16 53 47	9234 7651	8162 3766

9. MULTIPLY	10. MULTIPLY	11. DIVIDE	12. DIVIDE
769 7	697 6	67784 by 8	7398 by 9

13. ADD	14. ADD	15. SUBTRACT	16. SUBTRACT
834 257 196 432	35 26 47 18	8145 6876	8457 3598

17. MULTIPLY	18. MULTIPLY	19. DIVIDE	20. DIVIDE
976 5	208 12	29463 by 7	92732 by 4

GO STRAIGHT ON TO PAGE 3.

21. ADD

92
37
43
65

22. ADD

47
38
24
69

23. SUBTRACT

7337
3773

24. SUBTRACT

9463
6875

25. MULTIPLY

7865 × 5

26. MULTIPLY

4792 × II

27. DIVIDE

78417 by 9

28. DIVIDE

II077 by II

29. ADD

94
87
77
68

30. ADD

89
76
94
38

31. SUBTRACT

7436
5259

32. SUBTRACT

8365
4978

33. MULTIPLY

738 × 7

34. MULTIPLY

857 × 6

35. DIVIDE

7365 by 5

36. DIVIDE

35144 by 8

37. ADD

82
29
36
44

38. ADD

753
468
927
3I6

39. SUBTRACT

5257
2683

40. SUBTRACT

5603
5092

GO STRAIGHT ON TO PAGE 4.

41. MULTIPLY

6 3 7 I
I I

42. MULTIPLY

6 7 4 5
6

43. DIVIDE

8 2 7 5 by 5

44. DIVIDE

4 9 3 8 3 by 9

45. ADD

8 2 7
6 3 9
9 2 5
4 8 3

46. ADD

9 3 5 6 7
I 5 0 0 3
I 3
4 7 6

47. SUBTRACT

9 2 4 6
3 5 6 7

48. SUBTRACT

8 I 0 5 4 3
6 0 6 7 I 5

49. MULTIPLY

7 9 8
8

50. MULTIPLY

9 6 8
7

51. DIVIDE

5 2 9 8 3 by 7

52. DIVIDE

9 3 3 3 by 9

53. ADD

7 6
I 2 3
9
5 6 9
I 0 2 7

54. ADD

5 7
I 3 4
6 8
6 5 9
2 0 2 6

55. SUBTRACT

6 3 4 5 8 7
2 7 6 4 8 8

56. SUBTRACT

3 I 0 4 7 2
I 9 8 6 3 8

57. MULTIPLY

5 7 4
8 2

58. MULTIPLY

2 8 7
5 4

59. DIVIDE

3 6 6 5 9 by 7

60. DIVIDE

5 9 6 8 8 by 8

GO STRAIGHT ON TO PAGE 5

61. ADD

57I
928
686
I43
I474

62. ADD

9651
I786
2435
6948
3734

63. SUBTRACT

962034
682I75

64. SUBTRACT

927536
628448

65. MULTIPLY

473
8I

66. MULTIPLY

472
90

67. DIVIDE

59I60 by 60

68. DIVIDE

8648 by 23

69. ADD

I36
867
475
909
856
273

70. ADD.

438
547
783
906
695
874

7I. SUBTRACT

640I36
45I849

72. SUBTRACT

I3542
6937

73. MULTIPLY

70325
I09

74. MULTIPLY

872
49

75. DIVIDE

69003 by I87

76. DIVIDE

23052 by I7

77. ADD

378
469
I87
854
936
807

78. ADD

9I47
826
553I
8725
I374
2279

79. SUBTRACT

763I54
2I9077

80. SUBTRACT

453270
323407

LOOK OVER YOUR WORK UNTIL TIME IS UP.

DO NOT TURN OVER OR OPEN THIS BOOK UNTIL YOU ARE TOLD

MORAY HOUSE EXPERIMENTAL

PROBLEM ARITHMETIC TEST 1/R.

Not to be filled in by the Scholar	
Age in years, and completed months y. m.	
Page	Score
2	
3	
4	
TOTAL	
Signature of marker.	

Fill in the following particulars at once:-

1. Your Surname (In capital letters).....
2. Your Christian Name(s) (In capital letters).....
3. Sex (Boy or Girl).....
4. Name of your school.....
5. Class you are in.....
6. Your Age.....years.
7. Date of Your Birthday.....
8. Today's Date.....

Here are some examples of the sums you have to do in this test. See if you can do them.

You may work the sums in your head; or you may do your working on the page if you wish.

1. How many inches are there in 3 yds.? _____ inches

2. What fraction of a stone is 7 lbs? Give your answer in its lowest terms. _____

3. How many seconds are there in $3\frac{1}{2}$ minutes? _____ seconds

4. How many pieces of wood each 3 in. long can be got out of a plank 7 ft. 9 in. long? _____ pieces

Correct your answers. You should have:- (1) 108, (2) $\frac{1}{2}$, (3) 210, and (4) 31.

Now read the following carefully.

1. All the questions that follow are problems like those you have just done.

2. When you are told to begin, turn to page 2 and start working at once.

3. Work as quickly and as carefully as you can.

4. Make any alterations in your answers clearly.

5. You may work the sums in your head; or you may do your working on the page if you wish.

6. You will have 45 minutes. No one is expected to do everything. Just do as much as you can.

DO NOT TURN OVER UNTIL YOU ARE TOLD.

1. How many yards are there in half a mile? _____ yards

2. How many stones are there in half a ton? _____ stones

3. How many pints are there in 2 quarts? _____ pints.

4. How many pounds are there in 3 cwts? _____ pounds

5. How many inches are there in 7 yds? _____ inches

6. How many pence are there in 13s. 4d? _____ pence

7. How many half-pint glasses could you fill from one gallon of milk? _____ glasses

8. How many 1-lb packets could you fill from $1\frac{1}{2}$ cwts. of tea? _____ packets

9. How many yards are there in a furlong? _____ yards.

10. How many 2 oz. blocks of chocolate can be got from 5 lbs. of chocolate? _____ blocks.

11. Two pieces of rope 8 yds. 2 ft. and 5 yds. 1 ft. long are joined together. What is the length of the piece so formed? _____ yds. _____ ft.

12. How many minutes are there in $2\frac{1}{2}$ hours? _____ minutes.

13. How many pints are there in $2\frac{1}{2}$ gallons? _____ pints

14. How many inches are there in 10 ft. 8 ins? _____ inches

15. How many pounds are there in 4 stones? _____ pounds

16. How many quarts are there in 5 gallons? _____ quarts

17. How many shillings are there in 5 guineas? _____ shillings

18. I arrived at the office at 9.30 a.m. and left at 1.0 p.m. How long was I there? _____ hrs. _____ min.

19. Multiply 3 lbs. 4 oz. by 10 _____ lbs. _____ oz.

20. A man weighs 10 st. 5 lbs. What is his weight in pounds? _____ pounds

21. Multiply 1 ft. 5 ins. by 3 _____ ft. _____ ins.

22. Multiply 2 yds. 2 ft. by 8 _____ yds. _____ ft.

23. How many pieces of wire, each 9 inches long, can be cut from a piece of wire $\frac{1}{4}$ mile long? _____ pieces

24. A boy is 4 ft. 5 ins. tall. What is his height in inches? _____ inches

25. A boy eats an apple a day. How many does he eat altogether in the months of April, May and June? _____ apples

26. I am 5 inches taller than my cousin who is 4 ft. 9 ins. How tall am I? _____ ft. _____ ins.

27. I need $\frac{1}{2}$ lb. of flour to make a cake. How many cakes can I make from 1 cwt. of flour? _____ cakes.

28. A boy weighs $5\frac{1}{2}$ stones. How many lbs. is this? _____ lbs.

29. What fraction of a yard is 2 ft? _____

30. What fraction of £1 is 7s 6d? Give your answer in its lowest terms. _____

GO STRAIGHT ON TO PAGE 3.

31. What fraction of a pound is 4 oz? Give your answer in its lowest terms. _____

32. What fraction of a day is 8 hrs? Give your answer in its lowest terms. _____

33. 50 cigarettes weigh 2 oz. How much tobacco is required to make 500 cigarettes? _____ lbs. _____ oz.

34. How many sixpences are there in £4. 2s. 6d. _____ sixpences

35. I waited for a train from a quarter to one until twenty-five minutes past one. How many minutes did I wait? _____ minutes

36. How many hours are there in a week? _____ hours

37. A boy saves a penny a day during the months of June, July, August and September. How much does he save? _____ s. _____ d.

38. A train travels 30 miles in an hour. How long will it take to travel 10 miles? _____ minutes

39. How many minutes are there in a day? _____ minutes

40. How many ounces are there in 40 lbs? _____ ounces

41. Two lengths of wood 6 yds. 2 ft. and 4 yds. 1 ft. long are placed end to end. What is the total length? _____ yds. _____ ft.

42. I arrived at a station at 11.53 a.m. and caught another train at 2.16 p.m. How long in hours and minutes did I have to wait? _____ hrs. _____ mins

43. A boy's stride is $2\frac{1}{2}$ ft. long. How many steps will he take to cover 10 yards? _____ steps

44. How many apples will there be in a hundredweight, if five apples on the average weigh 1 lb? _____ apples

45. How many lbs. of sugar are there in 2 tons? _____ lbs

46. A girl weighs 3 st. 9 lbs. What is her weight in lbs? _____ lbs

47. A motor car travelled 9 miles in 12 minutes. What was its speed in miles per hour? _____ m.p.h.

48. What is the distance round the edges of a square mat whose sides are each 4 ft. 3 in. long? _____ ft. _____ ins.

49. A boy walked 100 yards in a minute. What was his speed of walking in feet per second? _____ ft. per sec.

50. How many pieces of wire each 9 in. long can an electrician get from a piece 9 ft. long? _____ pieces

51. A milkman sells 80 quarts of milk. How many gallons has he sold? _____ gallons

52. How many $\frac{1}{4}$ lb. packets of tea can be made up from $\frac{1}{2}$ cwt. of tea? _____ packets

53. A tap pours forth water at the rate of $\frac{1}{4}$ pint per second. How many gallons does it pour out in 8 minutes? _____ gallons

54. 3 books together weigh $7\frac{1}{2}$ lbs. What is the weight in lbs of 7 similar books _____ lbs

55. If 21 cigarettes make up one ounce, how many cigarettes will make up $\frac{3}{4}$ lb? _____ cigarettes

GO STRAIGHT ON TO PAGE 4.

56. Four people use, amongst them, $\frac{1}{4}$ gallon of milk daily. How many pints of milk is this per person per week? _____ pints

57. A gallon of paraffin weighs 8 lbs. What is the weight of 3 pints? _____ lbs

58. Three pennies weigh 1 oz. and five half-pennies weigh 1 oz. I have a bag containing 24 pennies and 35 half-pennies. How much does the money weigh? _____ oz.

59. Three pieces of piping each 3 yd. 1 ft. long are placed end to end. What is their total length? _____ yds. _____ ft.

60. An empty packing case weighs 12 lb. If 6 books each weighing 3 lb. are packed in it, what will be the total weight? _____ lb.

61. How many pieces of string each 6 in. long can be cut from 20 yd. of string? _____ pieces

62. How many ounces are there in $6\frac{1}{4}$ lbs? _____ ounces

63. A bar of soap weighs 12 oz. How many bars are there in 3 cwt? _____ bars

64. 4 sheets of paper weigh 1 ounce. How many lbs will 128 sheets weigh? _____ lbs

65. A man weighs 12 stone 5 lbs. and his wife weighs 9 stone 8 lbs. How much heavier is the man than his wife? _____ st. _____ lbs

66. A stack of bricks is 10 feet high. If there are 40 layers of bricks in it, how high is each brick? _____ inches

67. How many furlongs are there in $6\frac{3}{4}$ miles? _____ furlongs.

68. Ribbon costs 8d per yard. What is the cost of $16\frac{1}{2}$ ft? _____ s. _____ d.

69. How many inches are there in 2 yd. 2 ft? _____ inches

70. A printing machine prints one page in 4 seconds. How many pages will it print in 8 minutes? _____ pages

71. Piping is laid down in pieces each 6 ft. long. How many pieces are required to lay a continuous pipe for $\frac{1}{4}$ mile? _____ pieces

72. If there are 8 sweets in an ounce, how many are there in $\frac{3}{4}$ lb? _____ sweets.

73. My watch gains 7 minutes per week. How many seconds does it gain per hour? _____ seconds

74. I have 8 yds. of wire. How many 4-inch lengths can I get from it? _____ lengths

LOOK OVER YOUR WORK UNTIL TIME IS UP.

APPENDIX II

Instructions for the Administration of the Tests.

TEST BATTERY - R.

INSTRUCTIONS FOR ADMINISTRATION OF TESTS.

I. GENERAL INSTRUCTIONS

1. It is essential that the following procedure should be adhered to exactly. In particular, great care must be exercised in the timing of the tests, and the supervisor should have a watch which has a seconds hand. If a stop watch is used, its accuracy should be confirmed by comparison with the seconds hand of an ordinary watch. If an ordinary watch is used, the minute hand should be adjusted so that it is on one of the minute divisions when the seconds hand is at zero.

2. The tests are answered in pencil on the pages of the test booklets. Ideally each child should be provided with two sharpened pencils before the test; alternatively, the supervisor should have a supply of spare pencils at hand in case any child breaks his pencil point during the test. In the latter case the children should be told before the test that anyone who breaks his pencil point should at once hold up his hand.

3. If possible, each child should have a desk to himself. Apart from the test booklets and pencils, no other working material is to be allowed; no rulers, india-rubbers, scribbling paper, pens, etc.

4. It is desirable that there be two supervisors in each room. One supervisor should stand at the desk facing the children, reading the instructions as required, keeping time with a watch before her, observing that no child looks at his neighbour's paper, and generally supervising the whole arrangements. She should not permit herself to be distracted by callers entering the room, by talking to anybody, by reading the test booklet herself, or by attempting to do work of her own during the period. Copying is comparatively easy with this type of examination and should be very carefully guarded against.

5. The second supervisor should patrol the room quietly and unobtrusively, carrying with her a reserve supply of pencils. Besides observing that no child copies, she should be on the alert to see that the children turn over the pages correctly, and that each child after completing one page goes straight on to the next without waiting for a signal. In general, she should see that the children carry out the instructions as to the method of answering to the best of their ability. As a rule, however, it will only be obvious blunderers who need a special eye upon them in these respects. There are usually a few who write when they have to underline, or vice versa, endeavour unnecessarily to rewrite questions or sums, or make some similar mistake. An indication with the finger or a whispered word of explanation is sufficient in these instances. Otherwise no assistance whatever is to be given.

6. Each test is preceded by a short practice test printed on page 1 of the test booklet (In the case of Space Test I/R the practice test occupies pages 1 & 2). It is worked by the class and supervisor together and is not scored. The aim of the practice test is to make sure that every child understands what he has to do and how to record his answers in the test proper. Use should be made of the blackboard to demonstrate to the pupils the correct way of recording their answers, and how to change an answer clearly by crossing out and rewriting.

II. ADMINISTRATION OF THE TESTS.

1. The test booklets are distributed with front page uppermost, the children having previously been warned not to turn over or open the booklets until they are told.

The supervisor should then supervise the filling in of such particulars as are asked for on the title page of the test. Some of the data may, if necessary, be written on the black board for the pupils to copy.

(Age and date of birth need be entered on the first test booklet only, and should be checked by the supervisor from the class register).

2. As soon as the children have filled in the title page, the supervisor should say: "To-day we are going to work some puzzles.* We shall do some of them together, and then you will do some yourselves. I want you all to try hard and do your best to answer correctly. Now open your books at page 1. Fold back the page." Illustrate how this is done. Make sure that all pupils are at page 1 and then say: "I shall read the rules which tell you what you have to do. You follow as I read them."

The supervisor then reads through the practice test instructions clearly and without haste, allowing time for the pupils to work the practice examples.

3. When satisfied that all pupils understand what they have to do and how to record their answers, the supervisor should call the class to attention and say: "Do you see where it says "Read the following carefully'? (holding up a test paper and pointing to the place). I shall read these rules to you, and you follow as I read them."

The supervisor then reads, beginning:-

1. All the questions.....

.....

5. You will have.....

4. As soon as the rules are read, the supervisor says: "When I say 'turn over', you are to turn over the paper, read for yourself the instructions at the top of the page≠ and begin working at once. Remember to work as quickly and as carefully as you can. Turn over, begin."

* ('questions in English',) whichever is appropriate to the test being worked.
('questions in Arithmetic',)

≠ In Problem Arithmetic Test I/R there are no instructions at the top of the page, so omit this phrase.

5. The supervisor writes down the exact time when she says "Begin," and also what the time will be 15, 30, and 45 minutes later.*

After 15 minutes she says: "A quarter of an hour has gone; you have half an hour* more."

After 30 minutes she says: "Half an hour has gone; you have a quarter of an hour* more."

After 45 minutes she says: Stop, pencils down."

6. The test booklets are then collected.

* These figures apply only to the following tests:-

Space Test I/R
Space Test 5/R
Mechanical Arithmetic Test 1/R
Problem Arithmetic Test 1/R.

For the other tests, the figures should be altered according to the time allowances indicated below:-

40 minutes for Space Test 2/R.
40 minutes " " " 3/R.
30 minutes " " " 4/R.
30 minutes " " " 6/R
30 minutes " Word Formation Test 1/R
30 minutes for No.-Letter Series Test 1/R.
25 minutes for Verbal Analogies Test 1/R.
20 minutes for Synonyms Test 1/R.
20 minutes for Word Series Test 1/R.

DIRECTIONS FOR THE ADMINISTRATION OF JENKIN'S TEST.

The times for each sub-test are as follows:-

Test I	5 minutes	2 pages
Test II	5 minutes	2 pages
Test III	5 minutes	2 pages
Test IV	5 minutes	2 pages
Test V	10 minutes	3 pages.

Procedure.

After the test-booklets have been distributed and the pupils have filled in the title page, the supervisor should say:- "Do you see where it says 'Read the following carefully'?" (holding up a test paper and pointing to the place.) "I shall read these rules to you, and you follow as I read them."

The supervisor then reads, beginning:-

In this book.....

If you alter.....

Give the pupils a minute to look at and to try the practice examples at the foot of the page. When all appear ready say:-

"When I tell you to turn over the page like this" (open the book and point to Test 1) "you will see a '1' at the top. You will commence there and do as much of these two pages as you can. You will have five minutes. Ready? Turn over the page. BEGIN."

Then note in minutes and seconds the time of commencement on the timing record below.

Stop the pupils after five minutes and also note in minutes and seconds when this is done.

Repeat the procedure with each sub-test. In the case of Sub-Test V say:- "You are to do as much of these last three pages as you can. You will have ten minutes. Ready? Turn over the page. BEGIN."

Timing Record.

	Time of Commencement. (mins. and secs.)	Time of completion. (mins. and secs.)
Test I (5 mins.)		
Test II (5 mins.)		
Test III (5 mins.)		
Test IV (5 mins.)		
Test V (10 mins.)		

Signed.....

(Supervisor.)

PLEASE RETURN THIS RECORD WITH THE SCRIPTS .

T E S T B A T T E R Y - R.

TIME-TABLE FOR THE ADMINISTRATION OF THE TESTS.

N.B. It is important that the tests should be given in the order shown in the following table:-

Day	Test	Time taken to administer*
Mon. May 9th	Space Test 2/R	55 minutes
Tues. May 10th	Space Test 6/R	50 minutes
	Word Series Test 1/R	30 minutes
Wed. May 11th	Mech. Arith. Test 1/R	55 minutes
Thurs. May 12th	Number and Letter Series Test 1/R	40 minutes
	Verbal Analogies Test 1/R	35 minutes
Fri. May 13th	Space Test 1/R	1 hour
Mon. May 16th	Space Test 3/R	55 minutes
Tues. May 17th	Space Test 4/R	45 minutes
	Synonyms Test 1/R	30 minutes
Wed. May 18th	Problem Arithmetic Test 1/R	55 minutes
Thurs. May 19th	Word Formation Test 1/R	40 minutes
	Jenkins' Test	35 minutes
Fri. May 20th	Space Test 5/R	1 hour

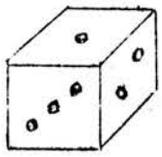
* This includes time taken to administer the practice test and time required for entering particulars on the title page.

Ideally, the tests should be administered early in the forenoon.

On the days when two tests are administered, a short break between them is desirable.

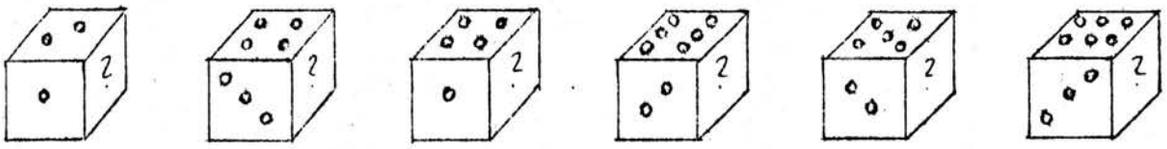
Now do the following questions in the same way as those you have just done. The first question has been done for you.

Here to help you is a drawing of Die A. Remember it has:

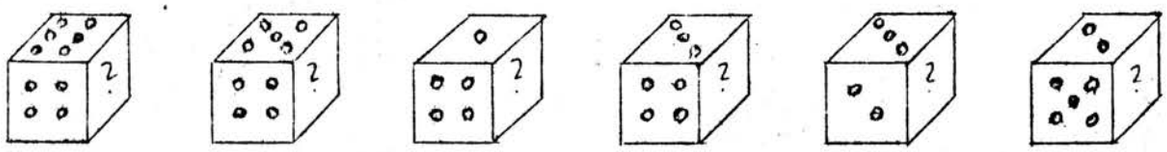


DIE A.

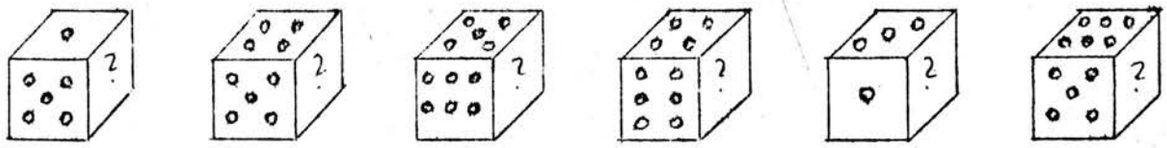
Number 1 opposite number 6,
Number 2 opposite number 4 and
Number 3 opposite number 5.



(1) 3 (2) _____ (3) _____ (4) _____ (5) _____ (6) _____



(7) _____ (8) _____ (9) _____ (10) _____ (11) _____ (12) _____

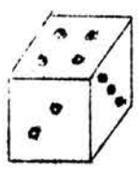


(13) _____ (14) _____ (15) _____ (16) _____ (17) _____ (18) _____

On the next page there are some more questions with a new die, which we will call Die B. Die B has its numbers in different places from Die A.

TURN OVER TO PAGE 4 WITHOUT WAITING TO BE TOLD.

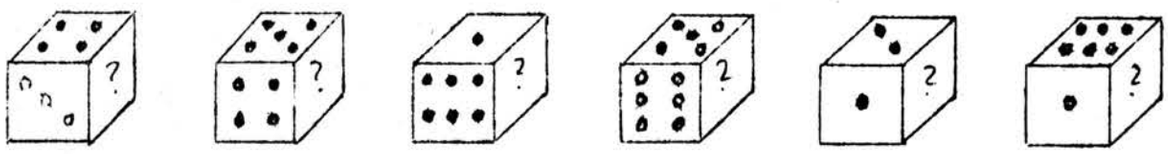
Here is a drawing of Die B, It is different from Die A. It has:



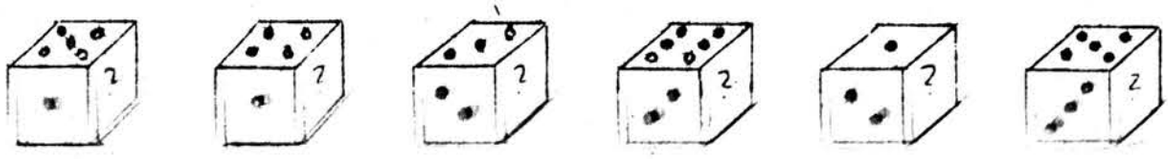
DIE B.

Number 1 opposite number 3,
Number 2 opposite number 5 and
Number 4 opposite number 6.

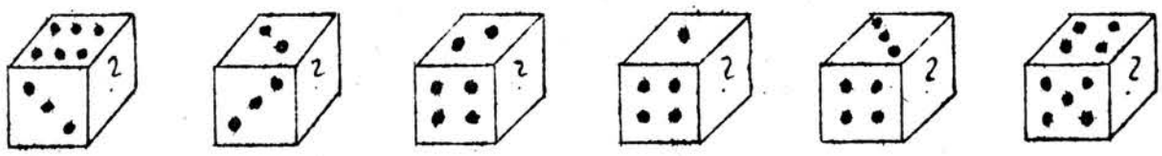
The first two questions have been done to help you. Now go ahead.



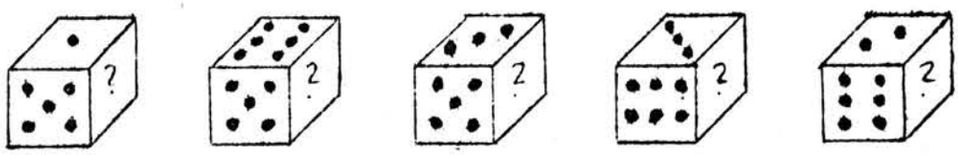
(19) 5 (20) 3 (21) _____ (22) _____ (23) _____ (24) _____



(25) _____ (26) _____ (27) _____ (28) _____ (29) _____ (30) _____



(31) _____ (32) _____ (33) _____ (34) _____ (35) _____ (36) _____

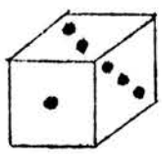


(37) _____ (38) _____ (39) _____ (40) _____ (41) _____

On the next page there are some more questions with a new die, which we will call Die C. Die C has its numbers in different places from Dice A and B.

TURN OVER TO PAGE 5 WITHOUT WAITING TO BE TOLD.

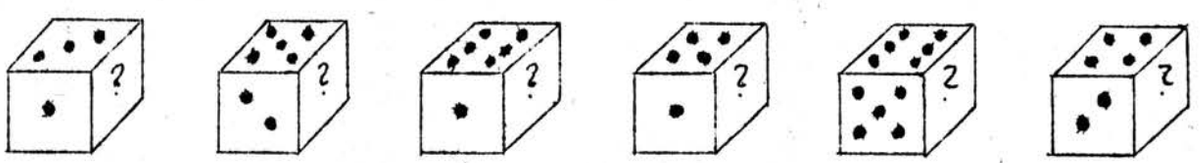
Here is a drawing of Die C. It is different from Dice A and B. It has:



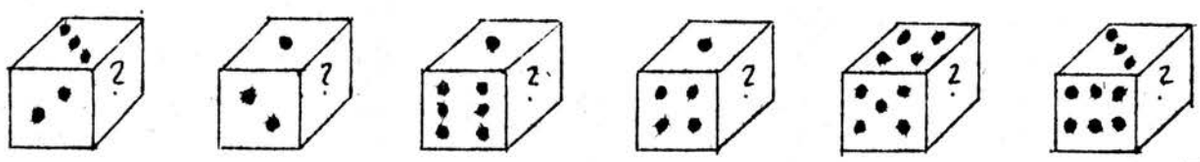
DIE C.

Number 1 opposite number 5,
Number 2 opposite Number 6 and
Number 3 opposite number 4.

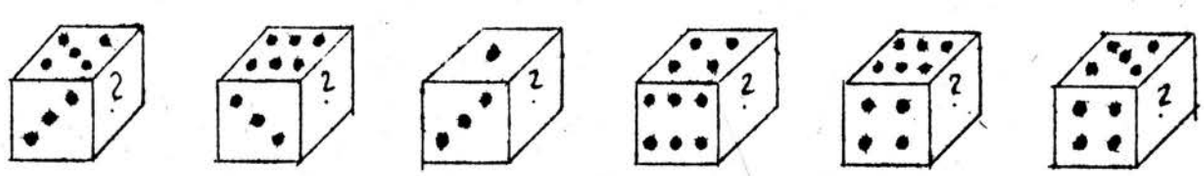
The first two questions have been done to help you. Now go ahead:



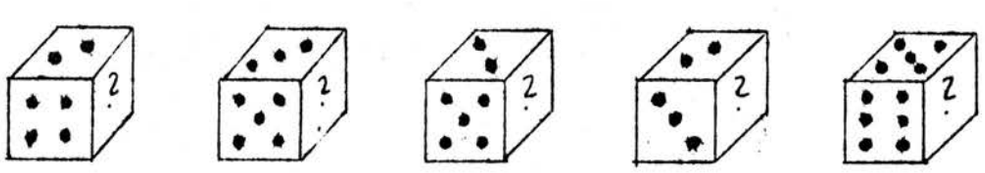
(42) 6 (43) 3 (44) ____ (45) ____ (46) ____ (47) ____



(48) ____ (49) ____ (50) ____ (51) ____ (52) ____ (53) ____



(54) ____ (55) ____ (56) ____ (57) ____ (58) ____ (59) ____

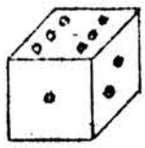


(60) ____ (61) ____ (62) ____ (63) ____ (64) ____

On the next page there are some more questions with a new die, which we will call Die D. Die D has its numbers in different places from Dice A, B and C.

TURN OVER TO PAGE 6 WITHOUT WAITING TO BE TOLD.

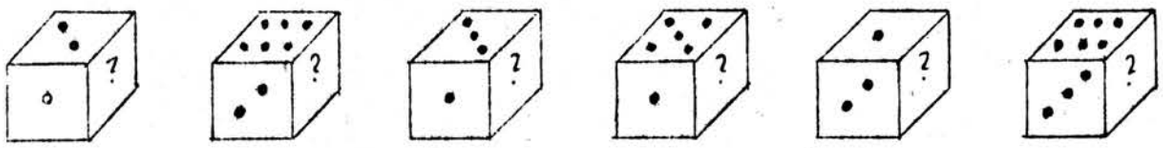
Here is a drawing of Die D. It is different from dice A, B and C. It has:



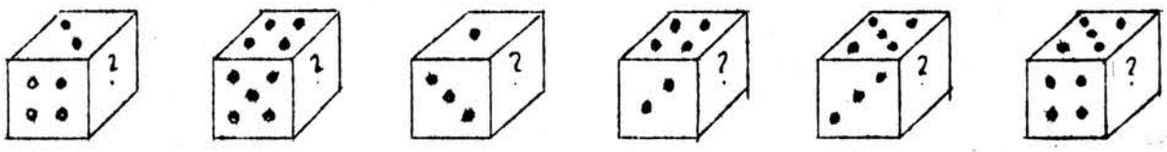
DIE D

Number 1 opposite number 4,
Number 2 opposite number 3 and
Number 5 opposite number 6.

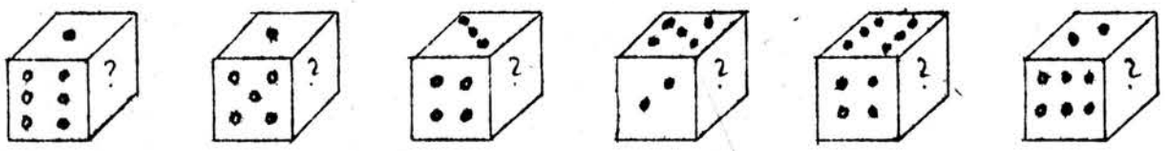
The first two questions have been done to help you. Now go ahead.



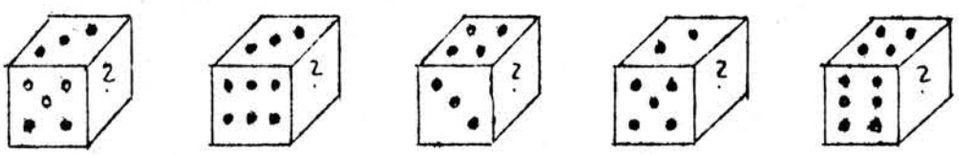
(65) 5 (66) 4 (67) ____ (68) ____ (69) ____ (70) ____



(71) ____ (72) ____ (73) ____ (74) ____ (75) ____ (76) ____



(77) ____ (78) ____ (79) ____ (80) ____ (81) ____ (82) ____



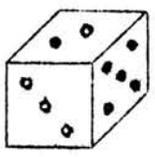
(83) ____ (84) ____ (85) ____ (86) ____ (87) ____

On the next page there are some more questions with a new die, which we will call Die E. Die E has its numbers in different places from Dice A, B, C and D.

TURN OVER TO PAGE 7 WITHOUT WAITING TO BE TOLD.

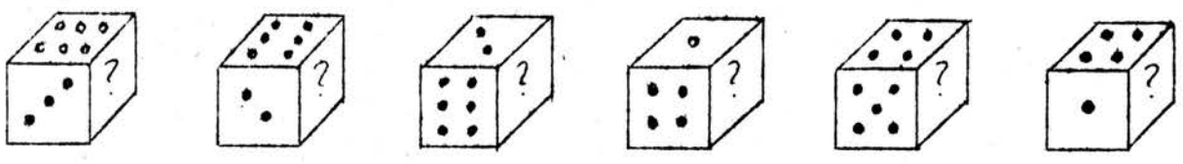
Here is a drawing of Die E. It is different from dice A, B, C and D. It has:

Number 1 opposite number 2,
Number 3 opposite number 4 and
Number 5 opposite number 6.

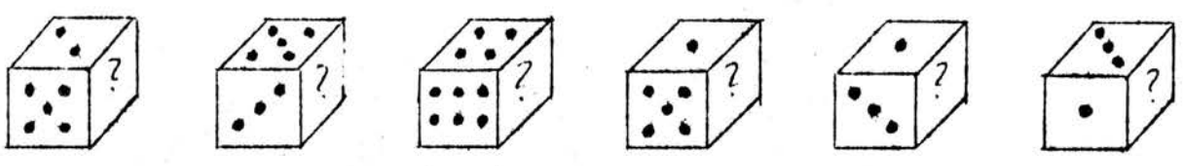


DIE E.

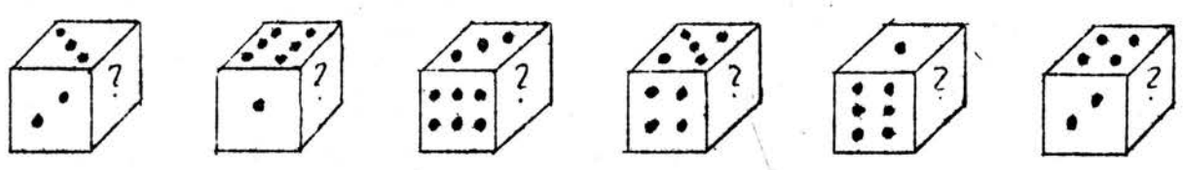
The first two questions have been done to help you. Now go ahead.



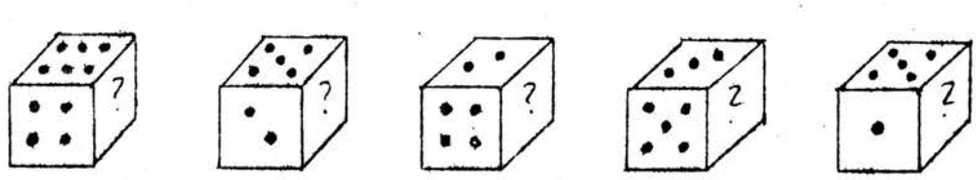
(88) 2 (89) 4 (90) _____ (91) _____ (92) _____ (93) _____



(94) _____ (95) _____ (96) _____ (97) _____ (98) _____ (99) _____



(100) _____ (101) _____ (102) _____ (103) _____ (104) _____ (105) _____



(106) _____ (107) _____ (108) _____ (109) _____ (110) _____

APPENDIX IV

Original Versions of the Space Tests.

DO NOT TURN OVER OR OPEN THIS BOOK UNTIL YOU ARE TOLD.

M O R A Y H O U S E E X P E R I M E N T A L

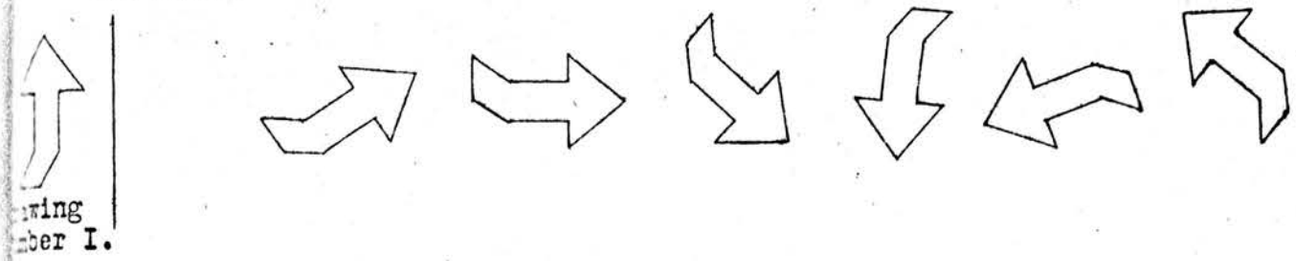
S P A C E T E S T I/R

Not to be filled in by the Scholar	
Age in years and completed months y. m.	
Page	Score
3.	
4.	
5.	
6.	
7.	
8.	
TOTAL	
Signature of Marker:	

Fill in the following particulars at once:-

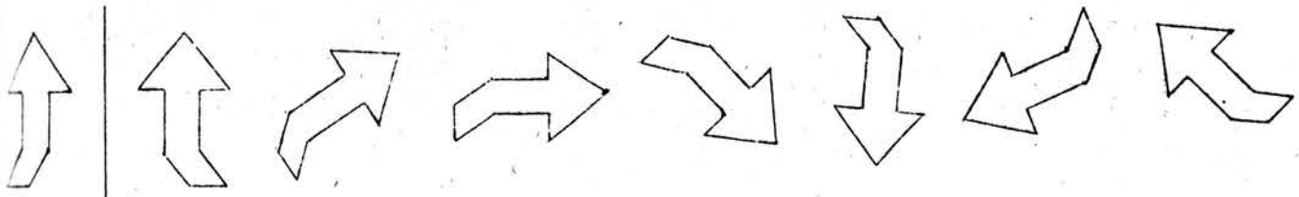
1. Your Surname (In capital letters).....
2. Your Christian Name(s) (In capital letters).....
3. Sex (Boy or Girl).....
4. Name of Your School.....
5. Class You are in.....
6. Your age.....years
7. Date of Your Birthday.....
8. Today's Date.....

Look at Drawing Number I in the row below.
Suppose we move it along the row and turn it round on the page. We can fit it exactly on top of each drawing, in turn.



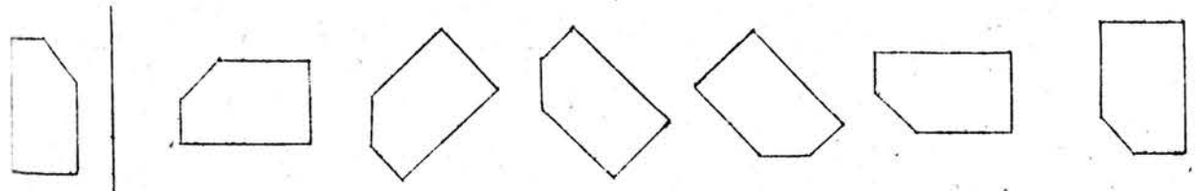
wing
ber I.

Look at Drawing Number I in the row below.
This time, by moving it along the row and turning it round on the page, we CANNOT exactly fit it on top of any of the drawings.



wing
ber I.

Now look at the next row of drawings.
If we move Drawing Number 2 along the row and turn it round on the page, we can fit it exactly on top of SOME of the drawings, but we cannot fit it on top of them all. You have to find out which drawings we can fit it over exactly.



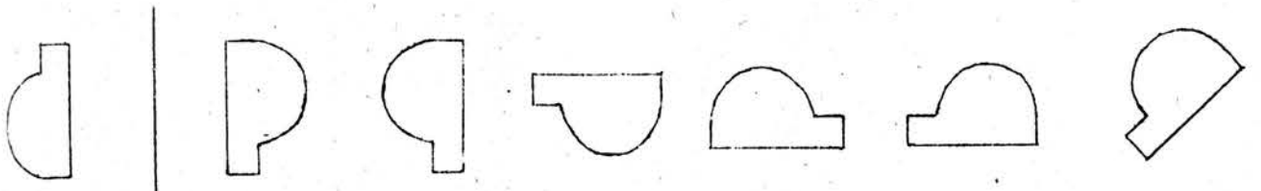
wing
ber 2.

(a) ✓ (b) ✓ (c) ____ (d) ✓ (e) ____ (f) ✓

We can fit Drawing Number 2 exactly on top of Drawings (a), (b), (d), and (f). So we have placed a tick (✓) on the line under each of them.

TURN OVER TO PAGE 2 WITHOUT WAITING TO BE TOLD.

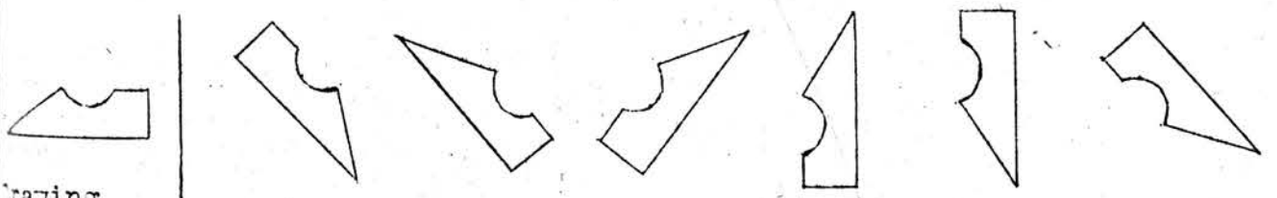
Look at the row of drawings below.
Place a tick (✓) under each drawing on top of which Drawing Number 3 fits exactly. Do not place a tick under those drawings which Drawing Number 3 does not fit.



Drawing Number 3 (a) ____ (b) ____ (c) ____ (d) ____ (e) ____ (f) ____

You should have placed a tick under drawings (a), (c), and (d).
Correct those you had wrong.

Now do another row in the same way. Place a tick (✓) under each drawing on top of which Drawing Number 4 fits exactly. Do not place a tick under those drawings which Drawing Number 4 does not fit.

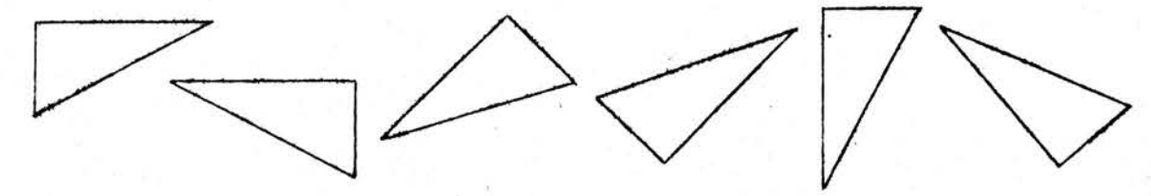


Drawing Number 4 (a) ____ (b) ____ (c) ____ (d) ____ (e) ____ (f) ____

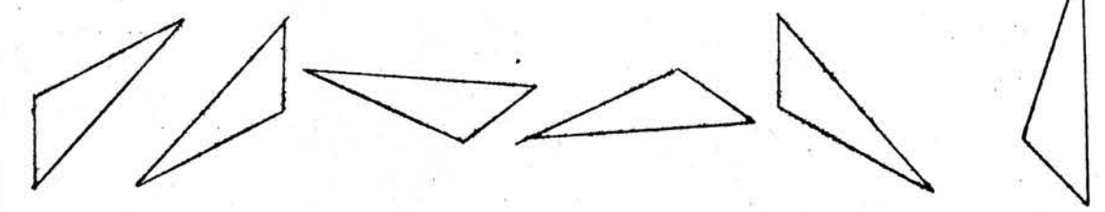
You should have placed a tick under drawings (b), (e), and (f).
Correct those you had wrong.

STOP HERE AND WAIT UNTIL YOU ARE TOLD TO BEGIN THE TEST.

Now do these questions in the same way. Place a tick under <u>each</u> drawing which is the same as the drawing on the left when turned round on the page. There is more than one answer to each question. Make any alterations in your answers <u>clearly</u>.



(a)____ (b)____ (c)____ (d)____ (e)____ (f)____



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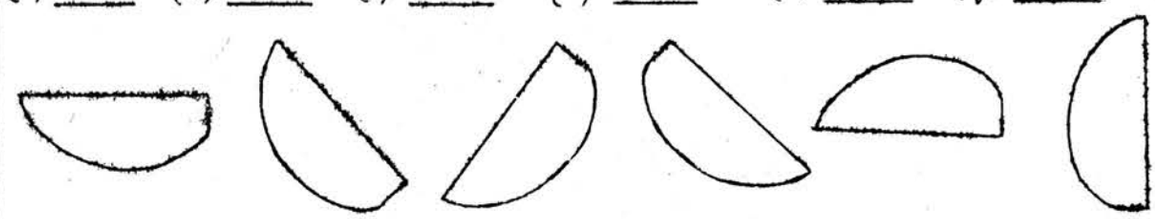

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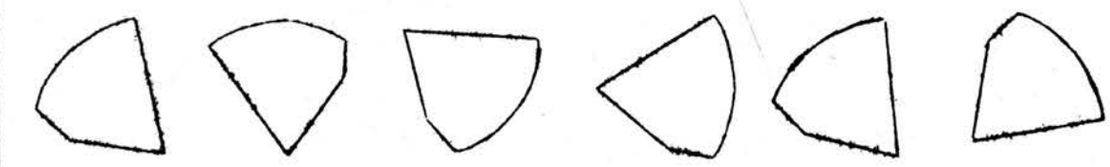

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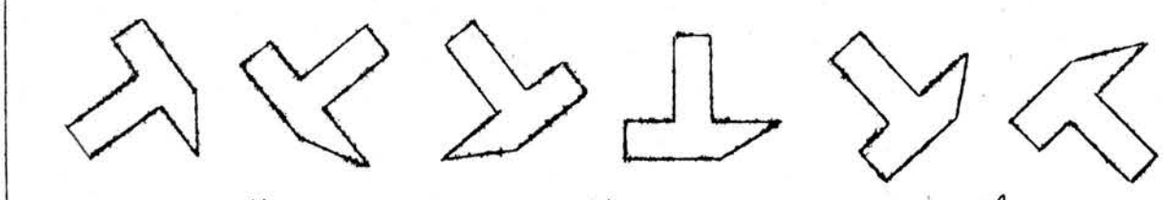
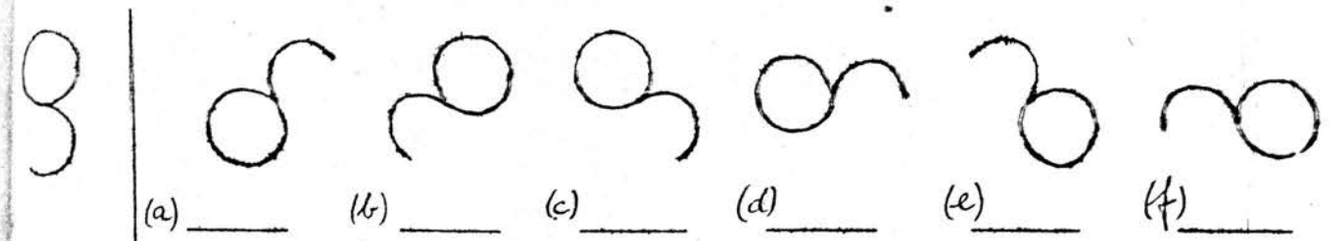
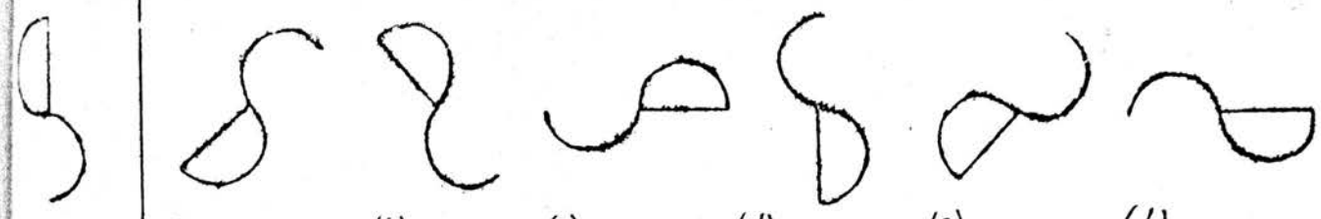


(a)____ (b)____ (c)____ (d)____ (e)____ (f)____

TURN OVER TO PAGE 4 WITHOUT WAITING TO BE TOLD.

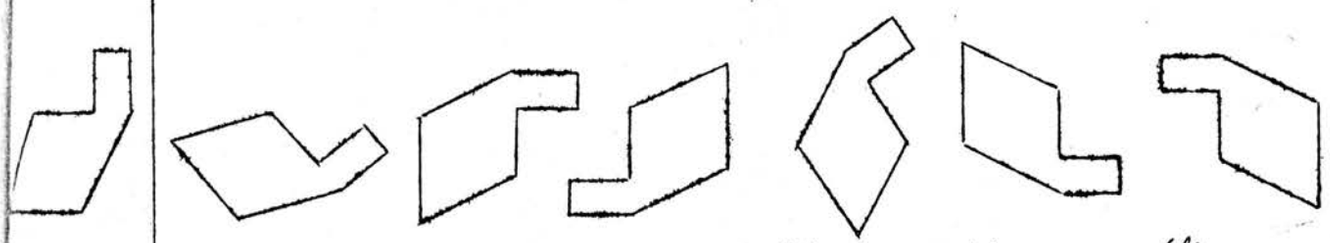


(a)____ (b)____ (c)____ (d)____ (e)____ (f)____



(a)____ (b)____ (c)____ (d)____ (e)____ (f)____

(a)____ (b)____ (c)____ (d)____ (e)____ (f)____



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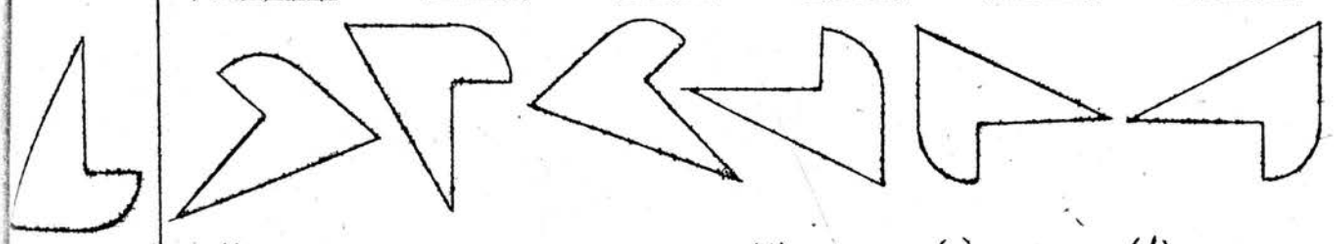

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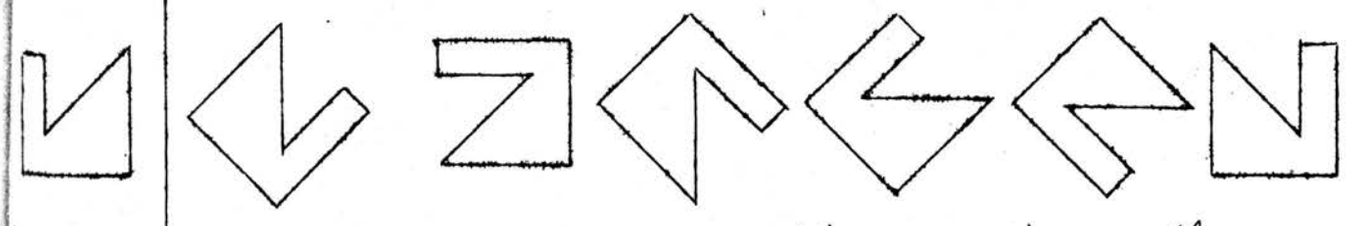

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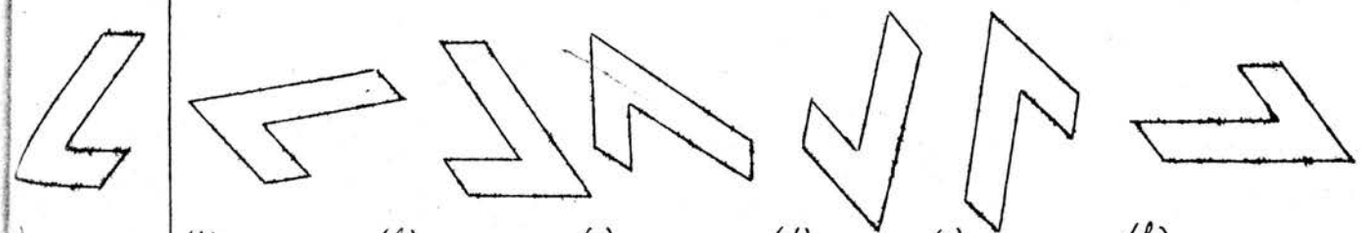
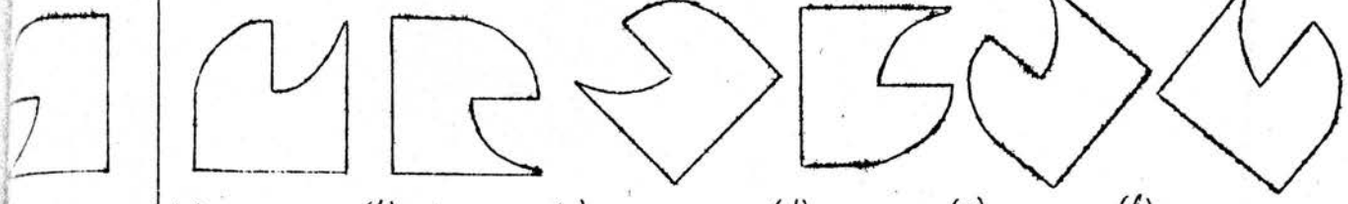
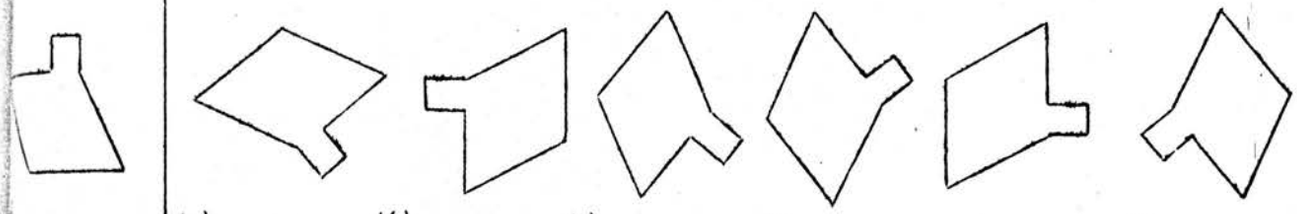


(a)____ (b)____ (c)____ (d)____ (e)____ (f)____

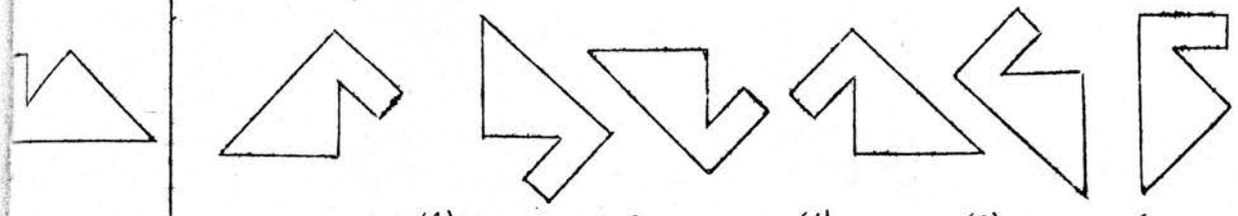
TURN OVER TO PAGE 5 WITHOUT WAITING TO BE TOLD.



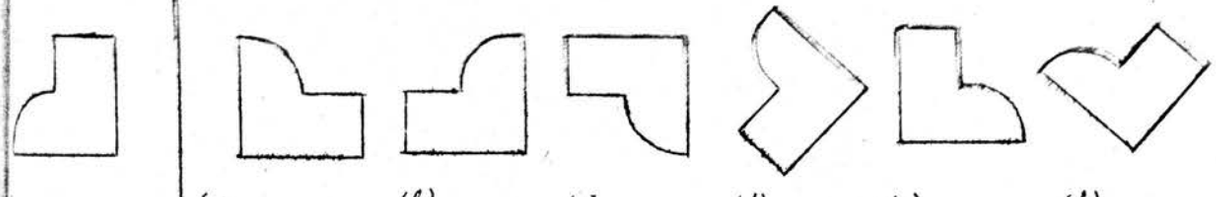
(a)____ (b)____ (c)____ (d)____ (e)____ (f)____



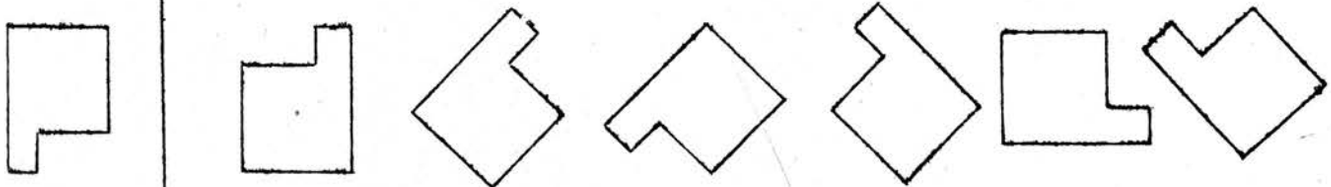
(a)____ (b)____ (c)____ (d)____ (e)____ (f)____



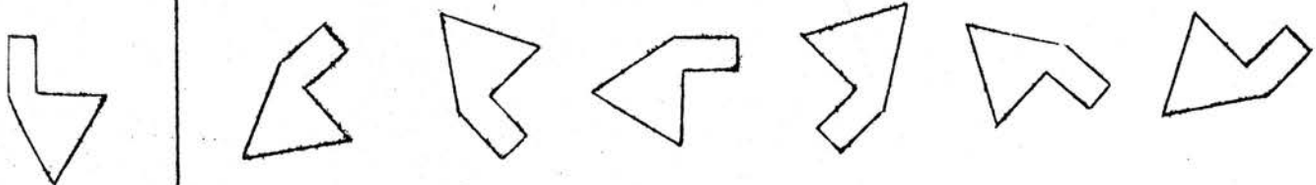
(a)____ (b)____ (c)____ (d)____ (e)____ (f)____



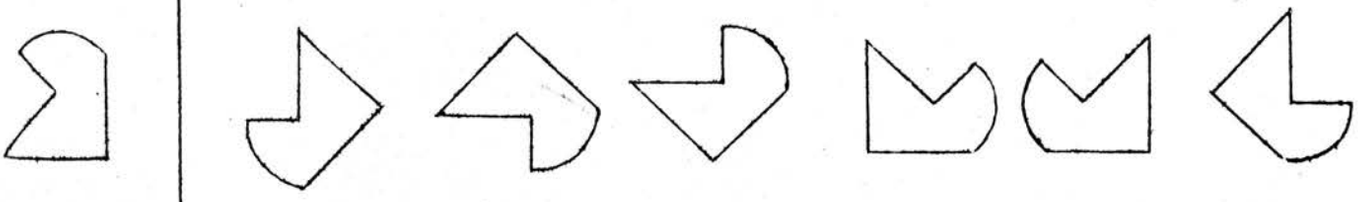
(a)____ (b)____ (c)____ (d)____ (e)____ (f)____



(a)____ (b)____ (c)____ (d)____ (e)____ (f)____

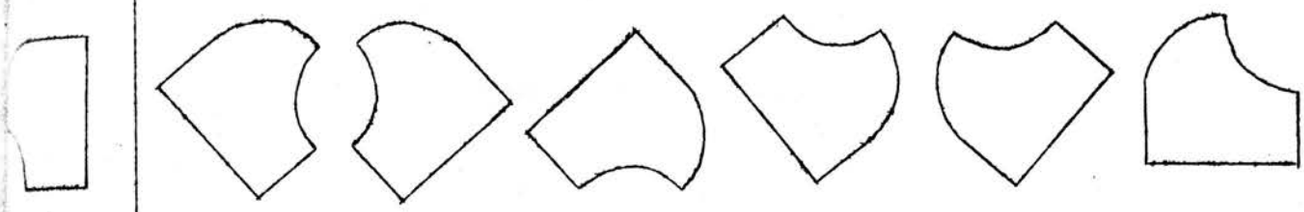


(a)____ (b)____ (c)____ (d)____ (e)____ (f)____

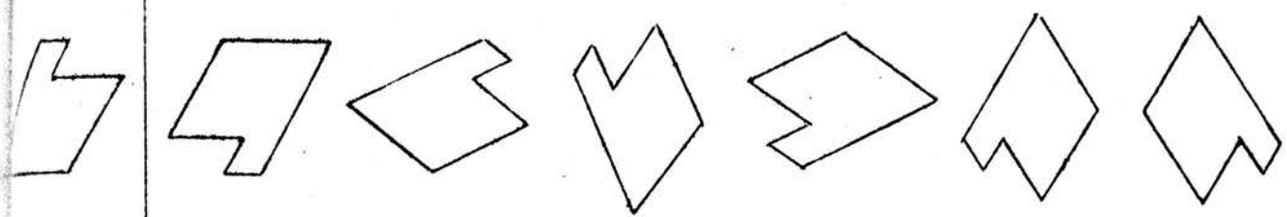


(a)____ (b)____ (c)____ (d)____ (e)____ (f)____

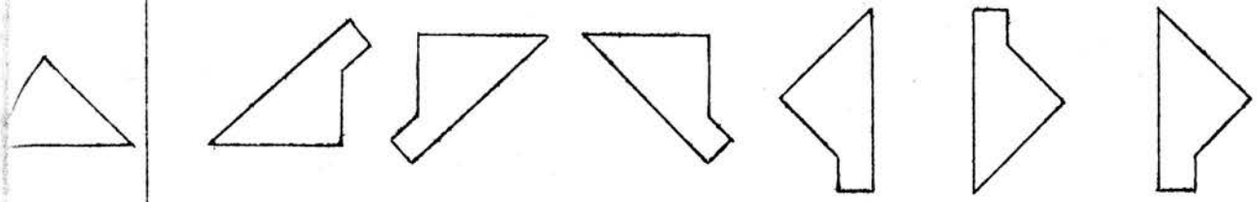
TURN OVER TO PAGE 6 WITHOUT WAITING TO BE TOLD.



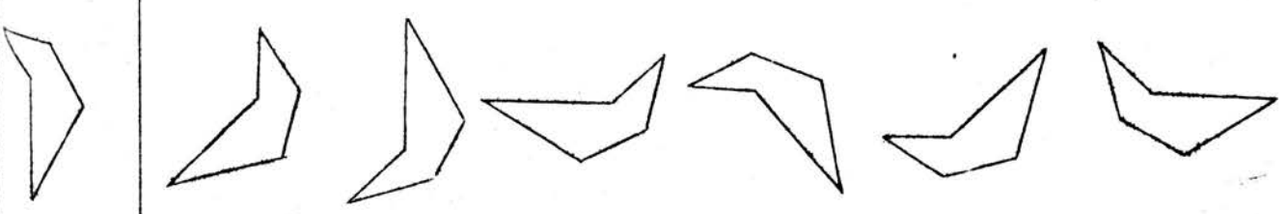
(a)____ (b)____ (c)____ (d)____ (e)____ (f)____



(a)____ (b)____ (c)____ (d)____ (e)____ (f)____

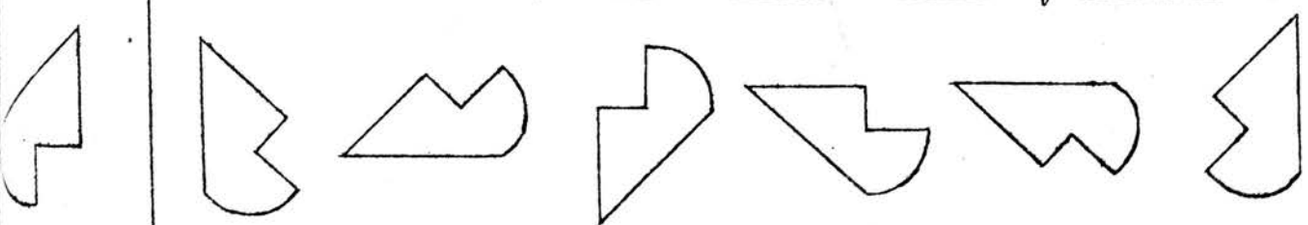


(a)____ (b)____ (c)____ (d)____ (e)____ (f)____



(a)____ (b)____ (c)____ (d)____ (e)____ (f)____

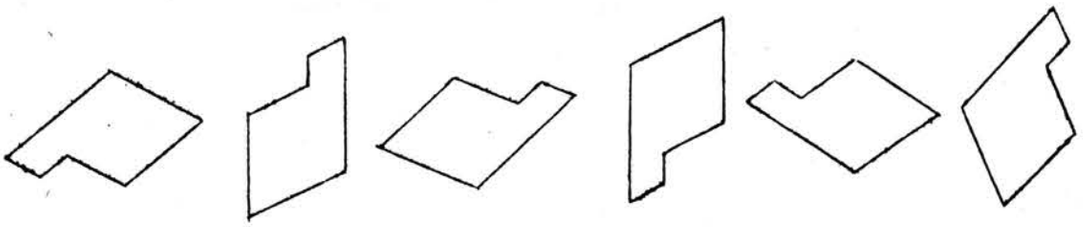
(a)____ (b)____ (c)____ (d)____ (e)____ (f)____



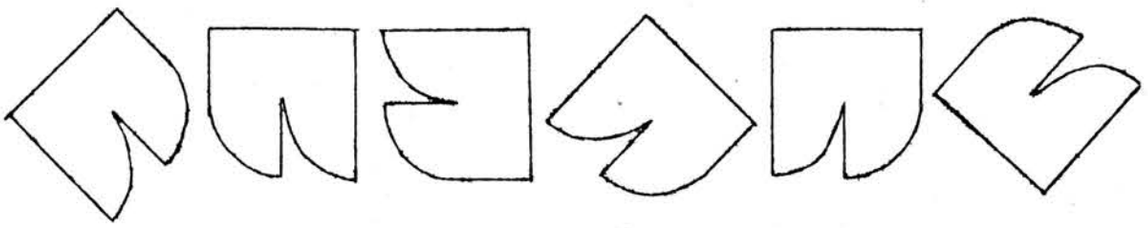
(a)____ (b)____ (c)____ (d)____ (e)____ (f)____

(a)____ (b)____ (c)____ (d)____ (e)____ (f)____

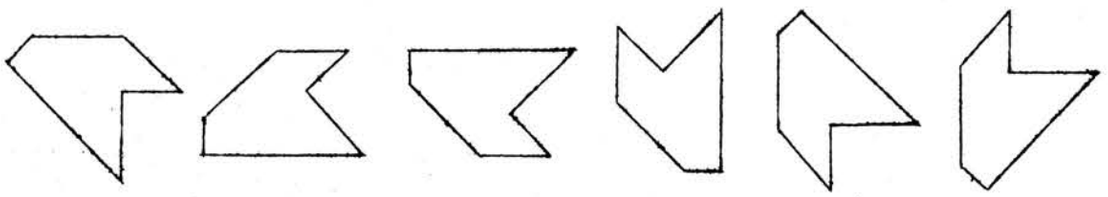
TURN OVER TO PAGE 7 WITHOUT WAITING TO BE TOLD.



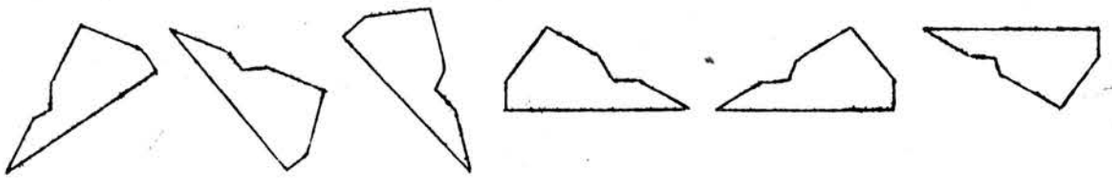
(a)_____ (b)_____ (c)_____ (d)_____ (e)_____ (f)_____



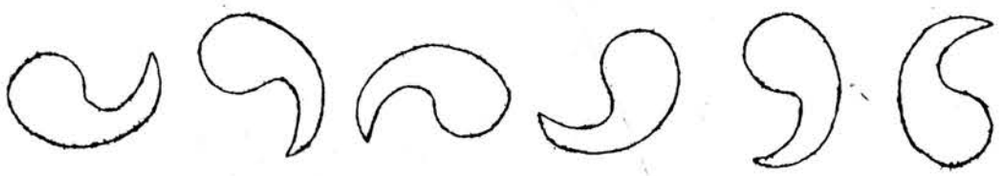
(a)_____ (b)_____ (c)_____ (d)_____ (e)_____ (f)_____



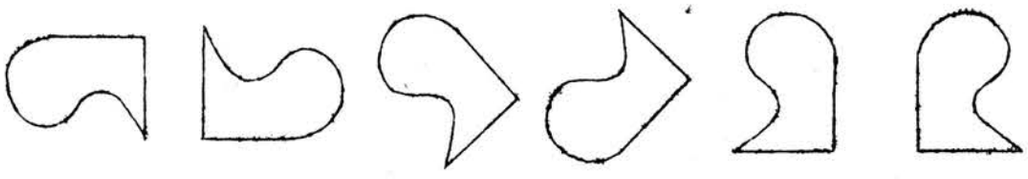
(a)_____ (b)_____ (c)_____ (d)_____ (e)_____ (f)_____



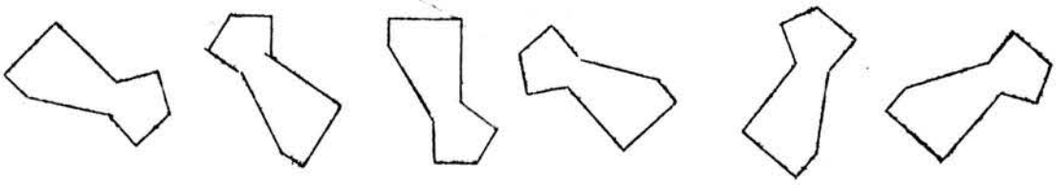
(a)_____ (b)_____ (c)_____ (d)_____ (e)_____ (f)_____



(a)_____ (b)_____ (c)_____ (d)_____ (e)_____ (f)_____

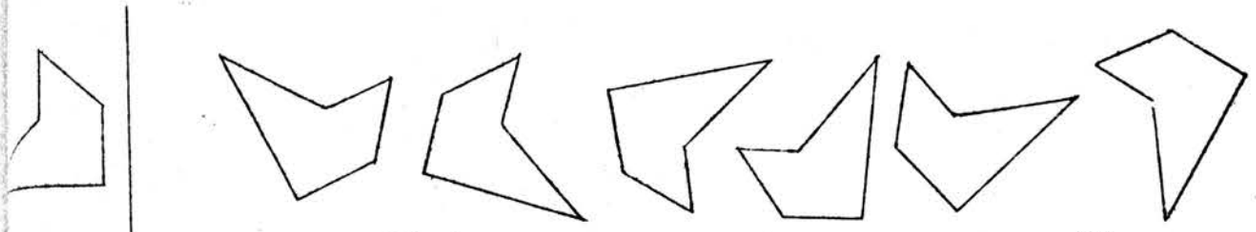


(a)_____ (b)_____ (c)_____ (d)_____ (e)_____ (f)_____

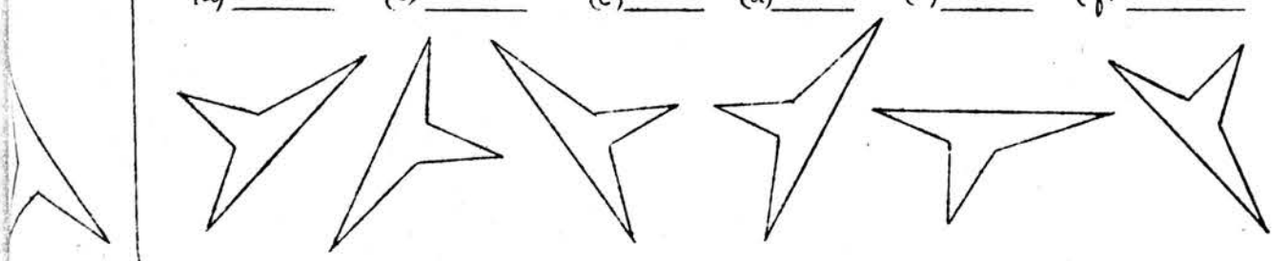


(a)_____ (b)_____ (c)_____ (d)_____ (e)_____ (f)_____

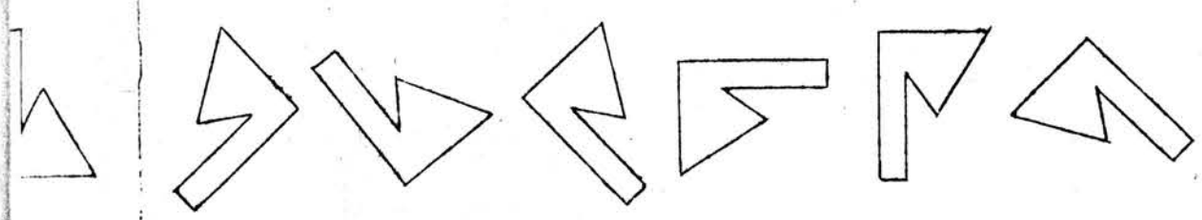
TURN OVER TO PAGE 8 WITHOUT WAITING TO BE TOLD.



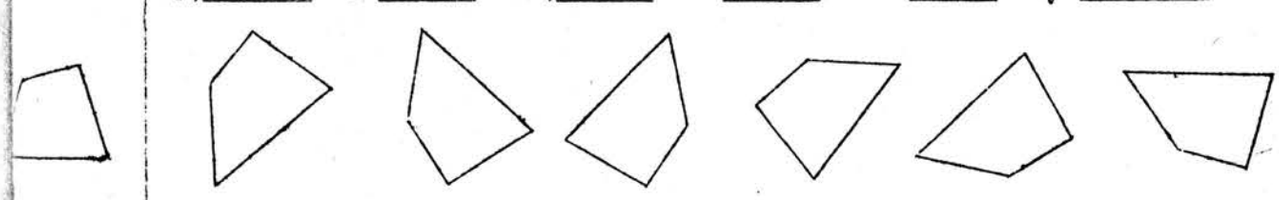
(a)____ (b)____ (c)____ (d)____ (e)____ (f)____



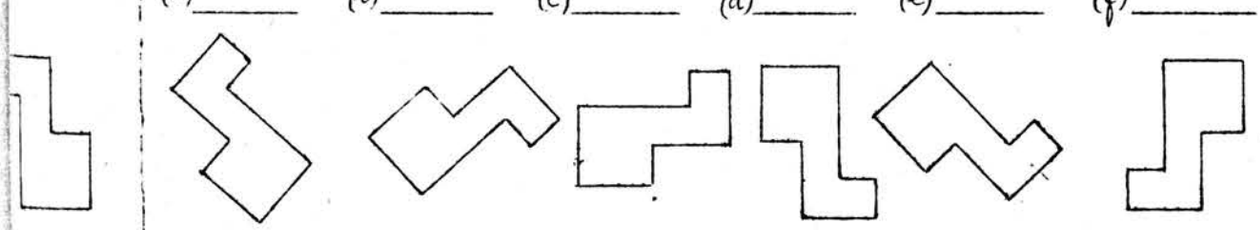
(a)____ (b)____ (c)____ (d)____ (e)____ (f)____



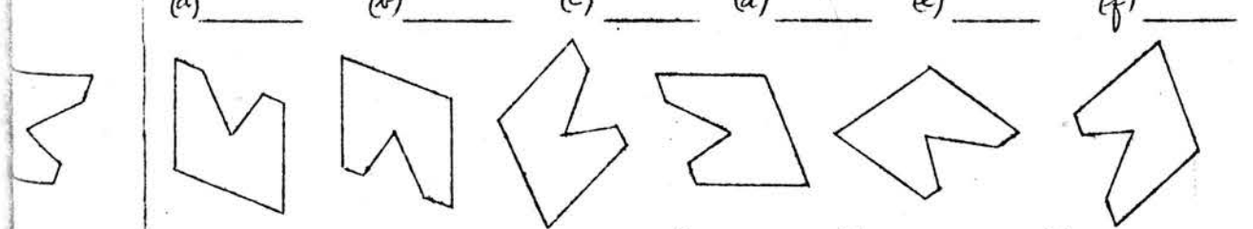
(a)____ (b)____ (c)____ (d)____ (e)____ (f)____



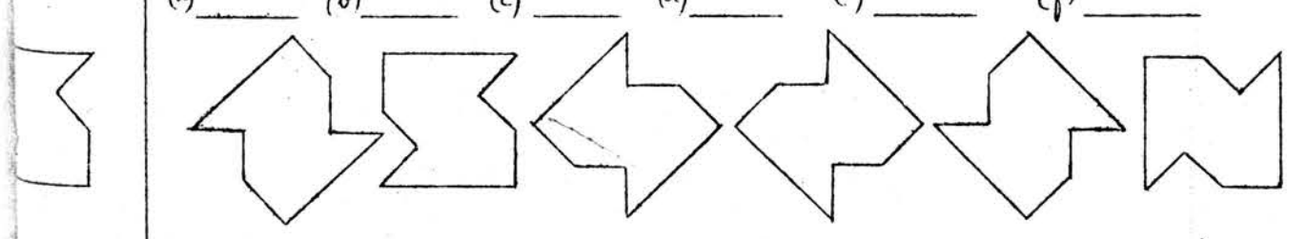
(a)____ (b)____ (c)____ (d)____ (e)____ (f)____



(a)____ (b)____ (c)____ (d)____ (e)____ (f)____



(a)____ (b)____ (c)____ (d)____ (e)____ (f)____



(a)____ (b)____ (c)____ (d)____ (e)____ (f)____

STOP HERE.

DO NOT TURN OVER OR OPEN THIS BOOK UNTIL YOU ARE TOLD.

M O R A Y H O U S E E X P E R I M E N T A L

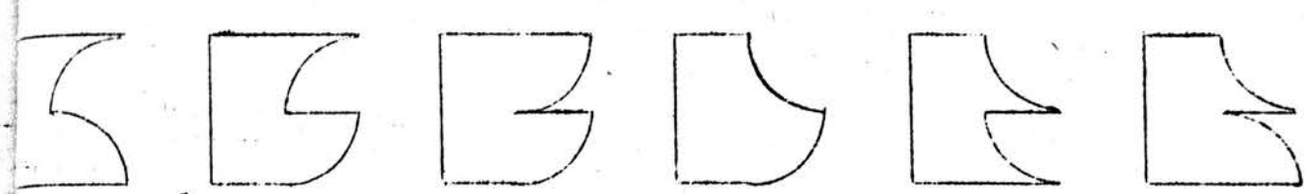
S P A C E T E S T 2/R.

Not to be filled in by the Scholar	
Age in years and completed months. y. m.	
Page	Score
2	
3	
4	
5	
TOTAL	
Signature of marker.	

Fill in the following particulars at once:-

1. Your Surname (In capital letters).....
2. Your Christian Name(s) (In capital letters).....
3. Sex (Boy or Girl).....
4. Name of your school.....
5. Class you are in.....
6. Your Age.....years.
7. Date of Your Birthday.....
8. Today's Date.....

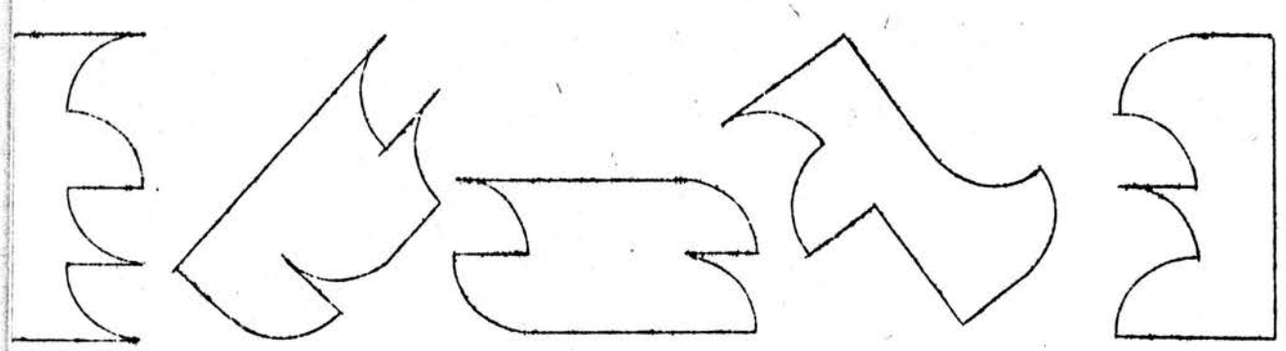
In the row below there are six different shapes, lettered A, B, C, D, E, and F.



A B C D E F

In the next row, there are some drawings which have been made by fitting together two of the shapes A, B, C, D, E, and F.

You have to find out which two shapes have been fitted together in each drawing, and write their letters on the line underneath. The first question has been done to help you. See if you can do the others.



A, E. (2) _____ (3) _____ (4) _____ (5) _____

Notice that some of the shapes have been turned over.

Now check your answers. You should have placed two letters under each drawing.

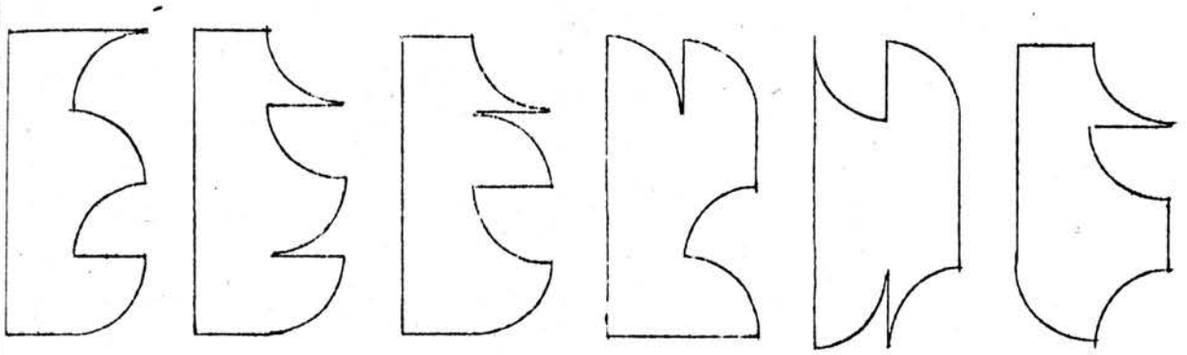
The answers are: (1) A,E. (2) C,E. (3) B,C. (4) A,D. (5) A,D.

The order of the letters does not matter.

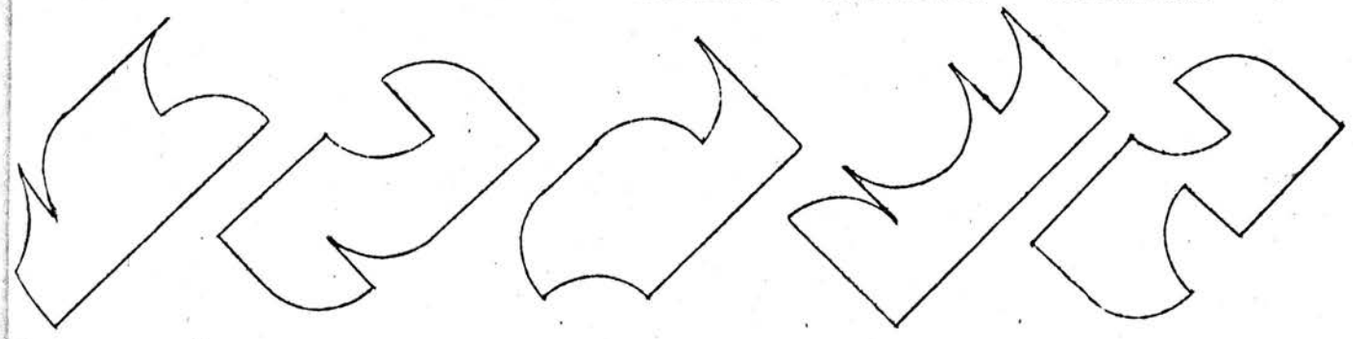
Now correct those you had wrong. Make the alterations clearly.

STOP HERE AND WAIT THE SIGNAL TO BEGIN THE TEST.

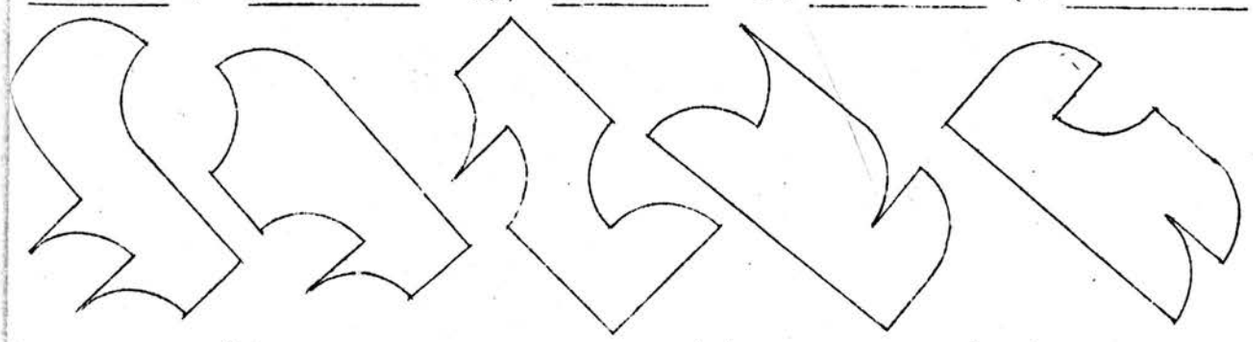
Now do these questions in the same way as those you have just done. In each drawing, find out which <u>two</u> shapes have been fitted together and write their letters on the line underneath. Make any alterations in your answers <u>clearly</u>.



(2) _____ (3) _____ (4) _____ (5) _____ (6) _____



(7) _____ (8) _____ (9) _____ (10) _____ (11) _____

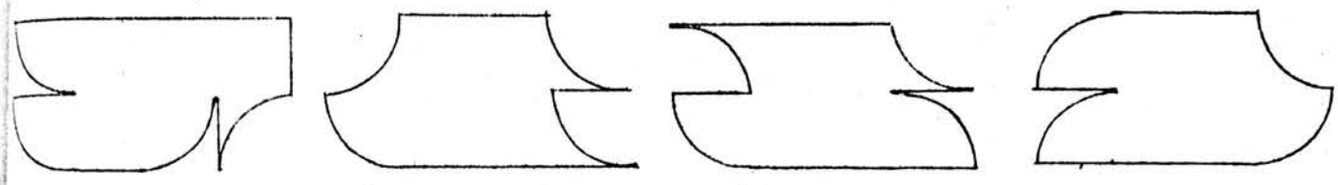


(12) _____ (13) _____ (14) _____ (15) _____ (16) _____

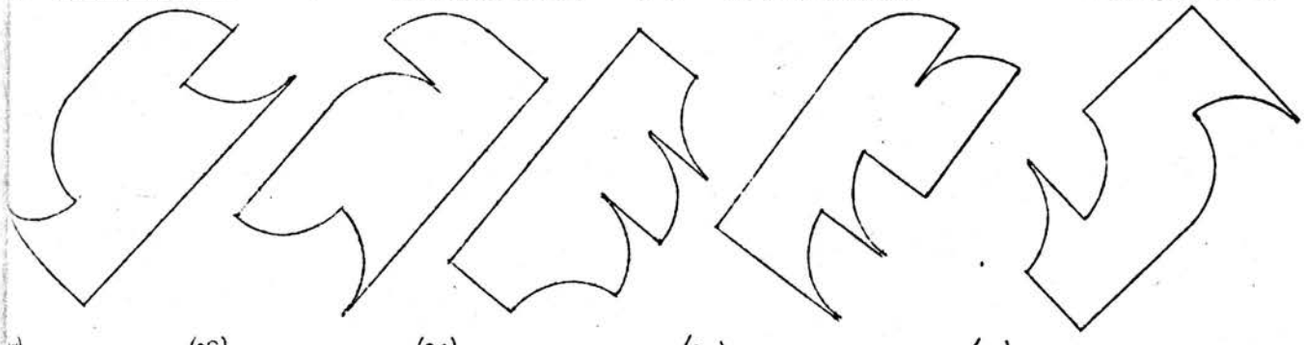
(17) _____ (18) _____ (19) _____ (20) _____ (21) _____ (22) _____

TURN OVER TO PAGE 3 WITHOUT WAITING TO BE TOLD.

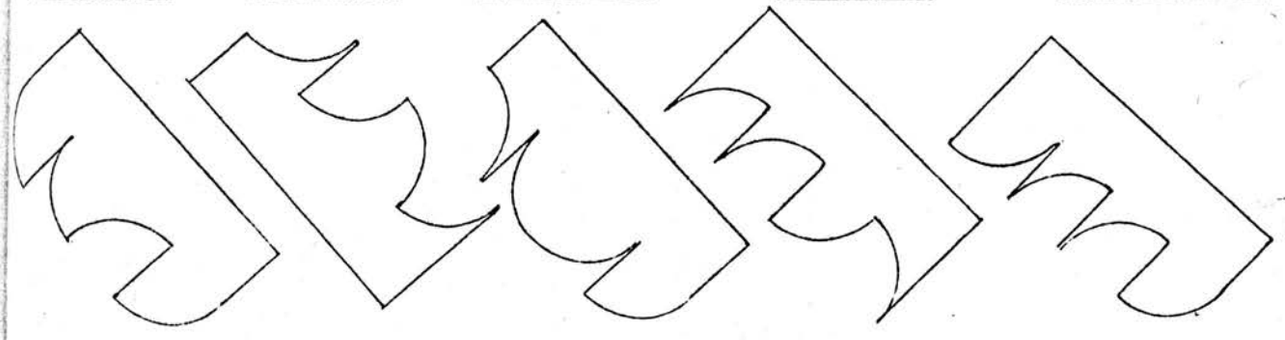
A B C D E F



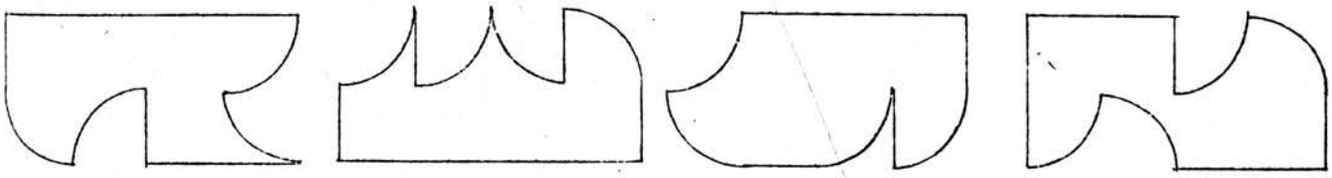
(23) _____ (24) _____ (25) _____ (26) _____



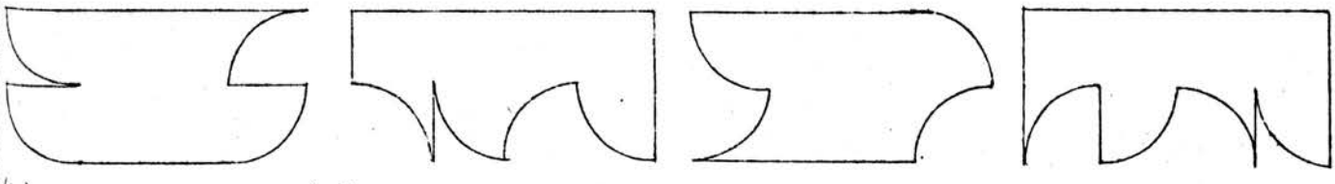
(27) _____ (28) _____ (29) _____ (30) _____ (31) _____



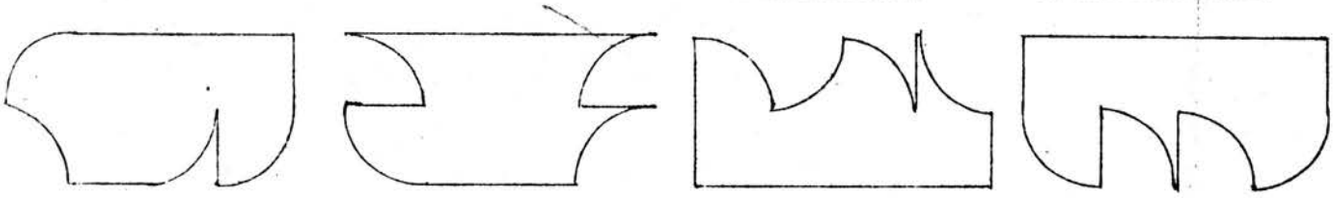
(32) _____ (33) _____ (34) _____ (35) _____ (36) _____



(37) _____ (38) _____ (39) _____ (40) _____

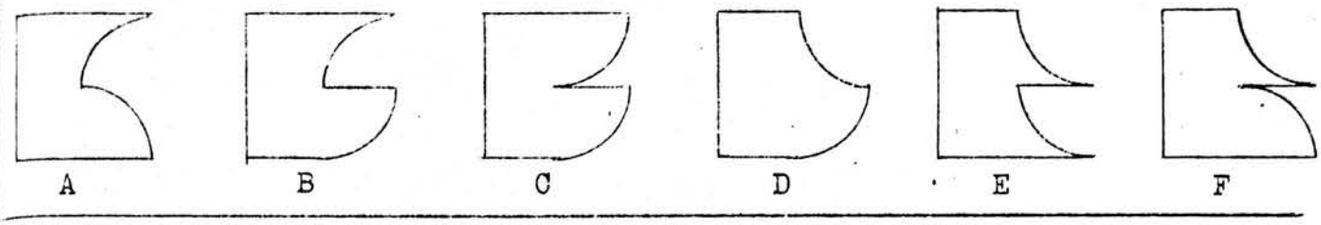


(41) _____ (42) _____ (42) _____ (43) _____

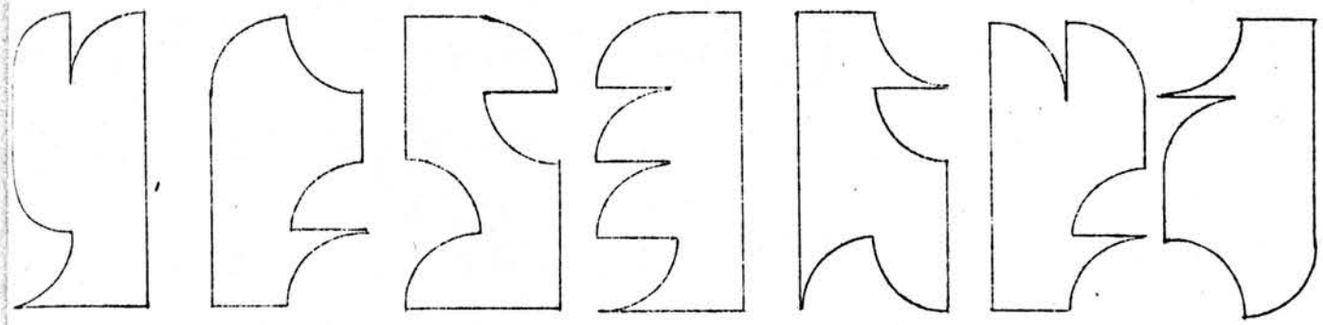


(44) _____ (45) _____ (46) _____ (47) _____

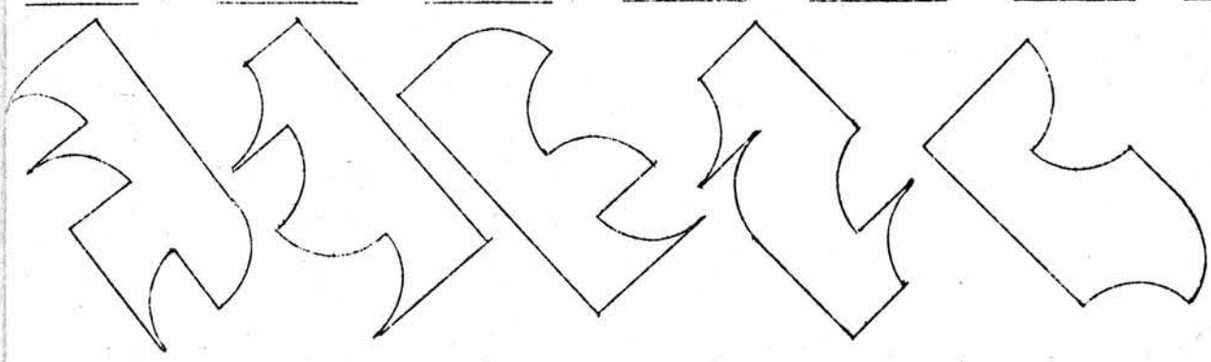
TURN OVER TO PAGE 4 WITHOUT WAITING TO BE TOLD.



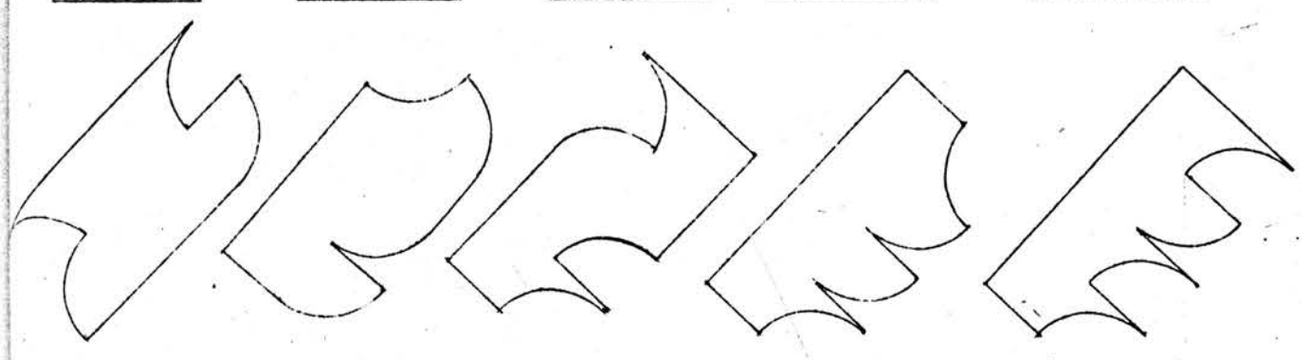
A B C D E F



(48) _____ (49) _____ (50) _____ (51) _____ (52) _____ (53) _____ (54) _____



(55) _____ (56) _____ (57) _____ (58) _____ (59) _____



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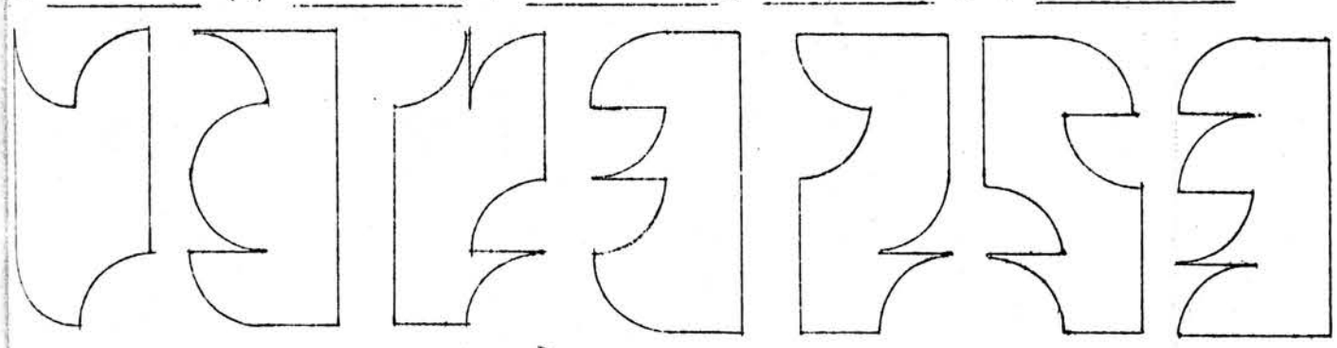
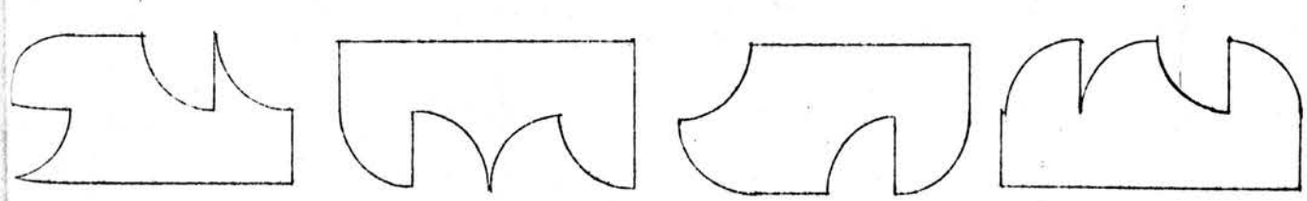
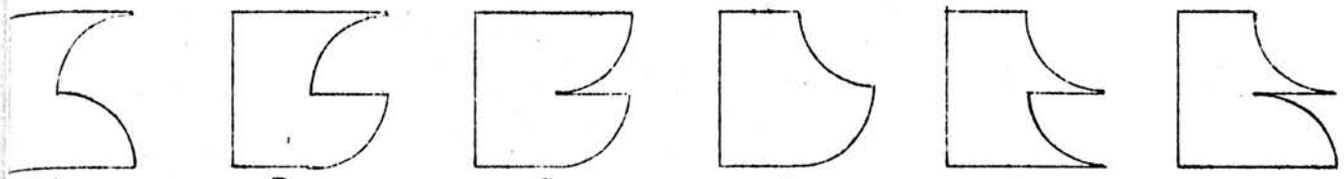


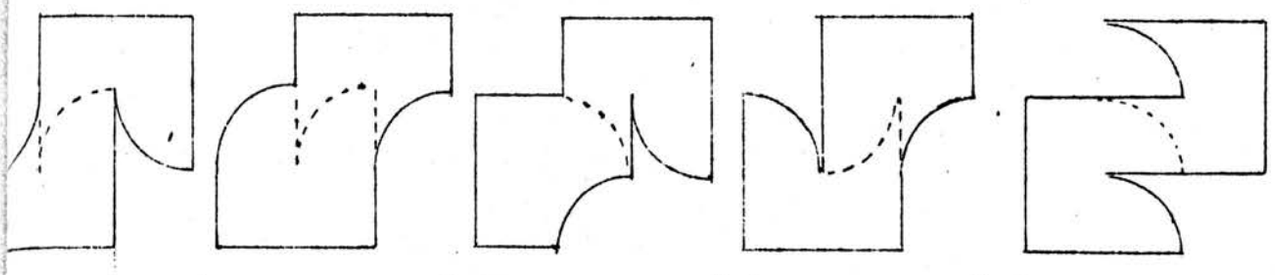
(65) _____ (66) _____ (67) _____ (68) _____ (69) _____ (70) _____ (71) _____



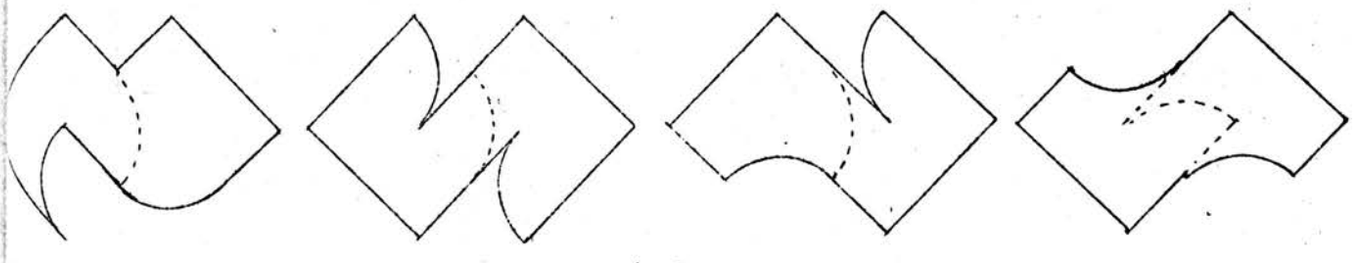
(72) _____ (73) _____ (74) _____ (75) _____

TURN OVER TO PAGE 5 WITHOUT WAITING TO BE TOLD.

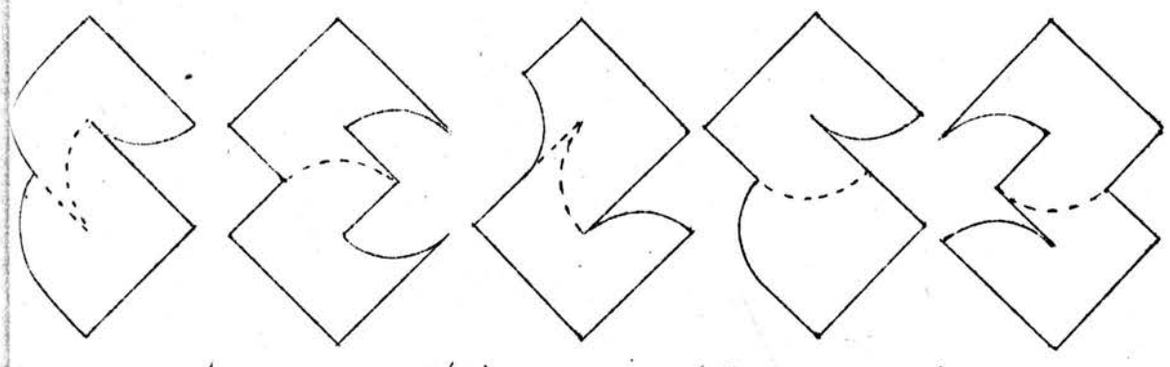




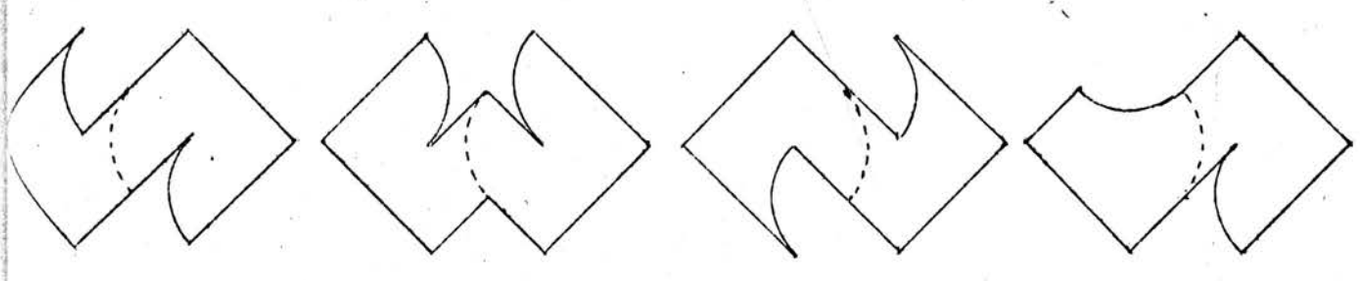
(77) _____ (78) _____ (79) _____ (80) _____



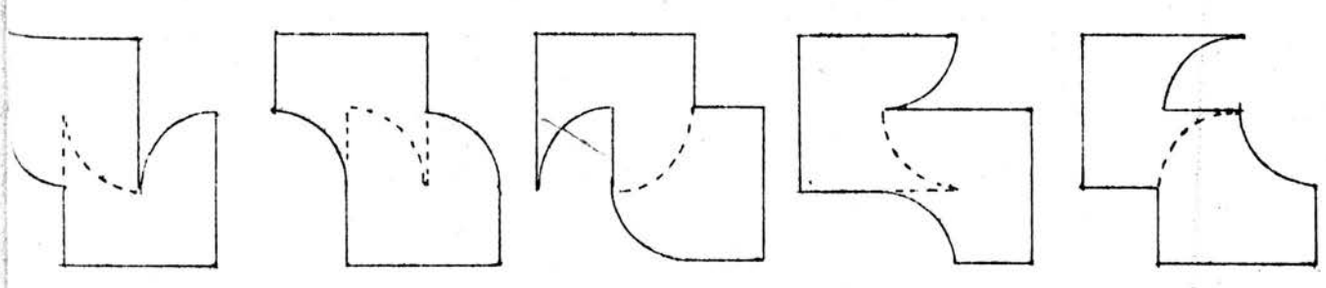
(82) _____ (83) _____ (84) _____



(86) _____ (87) _____ (88) _____ (89) _____



(91) _____ (92) _____ (93) _____



(95) _____ (96) _____ (97) _____ (98) _____

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MORAY HOUSE EXPERIMENTAL

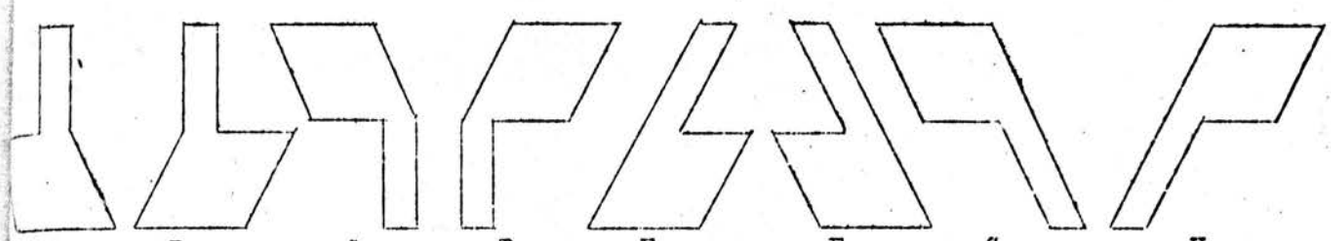
SPACE TEST 3R

Not to be filled in by the Scholar	
Age in years and completed months y. m.	
Page	Score
2.	
3.	
4.	
5.	
6.	
TOTAL	
Signature of Marker:	

Fill in the following particulars at once:-

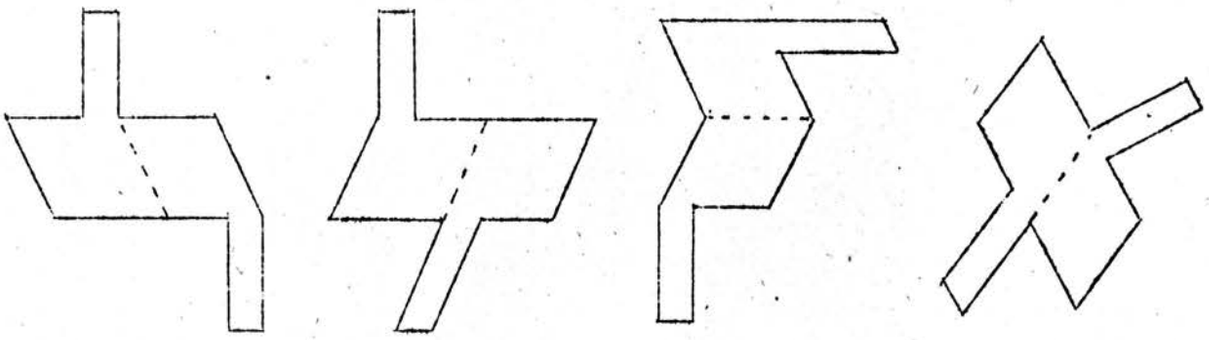
1. Your Surname (In capital letters).....
2. Your Christian Name(s) (In capital letters).....
3. Sex (Boy or Girl).....
4. Name of your school.....
5. Class you are in.....
6. Your age.....years
7. Date of Your Birthday.....
8. Today's Date.....

In the row below there are <u>eight</u> different shapes, lettered A, B, C, D, E, F, G, and H.



By moving the shapes <u>on the page</u>, and fitting them together we can make a new drawing. In the next row there are some drawings which have been made in this way— by fitting together <u>two</u> of the shapes A, B, C, D, E, F, G, and H.

You have to find out which <u>two</u> shapes have been fitted together in each drawing, and write their letters on the line underneath. The first question has been done for you. See if you can do the others. Be careful to see the difference between A and B , C and D , E and F , and G and H.

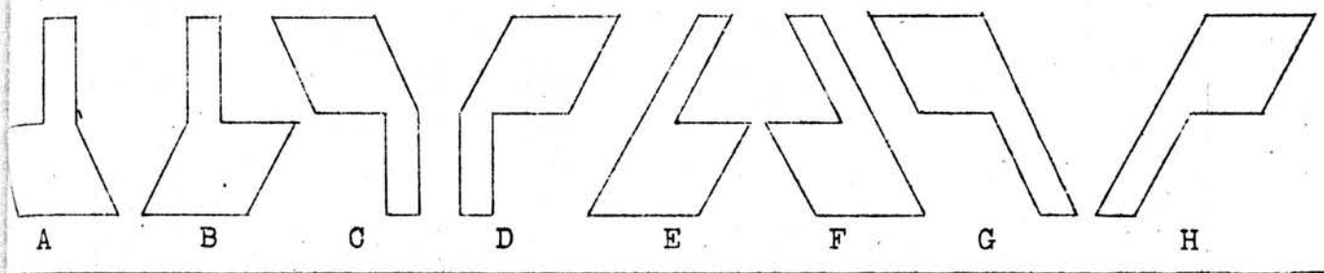


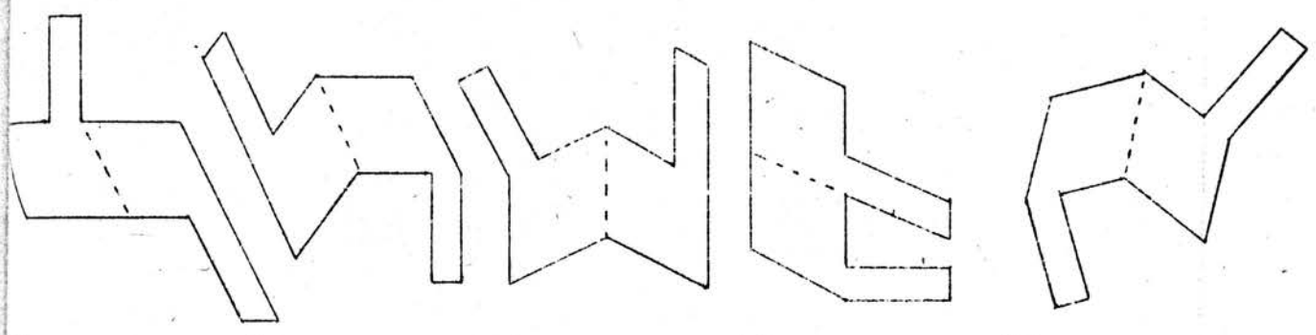
(1) A, C. (2) (3) (4)

You should have placed two letters under <u>each</u> drawing.
Now check your answers. They are: (1) A,C. (2) B,H. (3) D,E. (4) C,G.
The order of the letters does not matter.
Now correct those you had wrong. Make the alterations <u>clearly</u>.

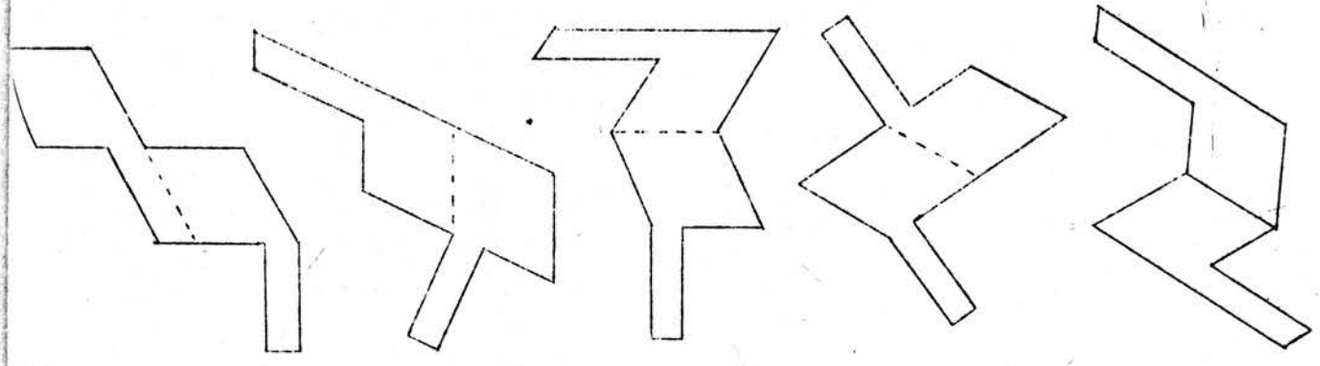
<u>STOP HERE AND WAIT THE SIGNAL TO BEGIN THE TEST.</u>

Now do these questions in the same way as those you have just done. In each drawing, find out which <u>two</u> shapes have been fitted together and write their letters on the line underneath. Make any alterations in your answers clearly.

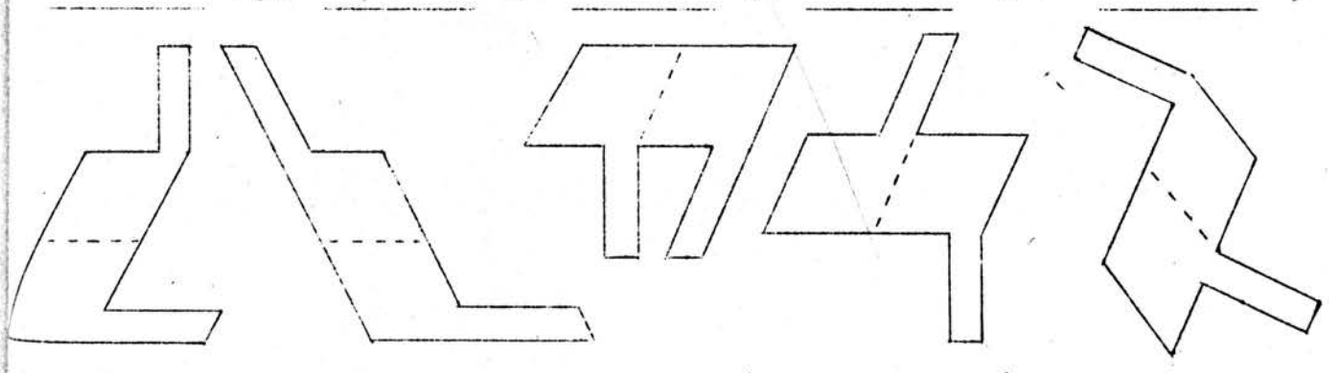




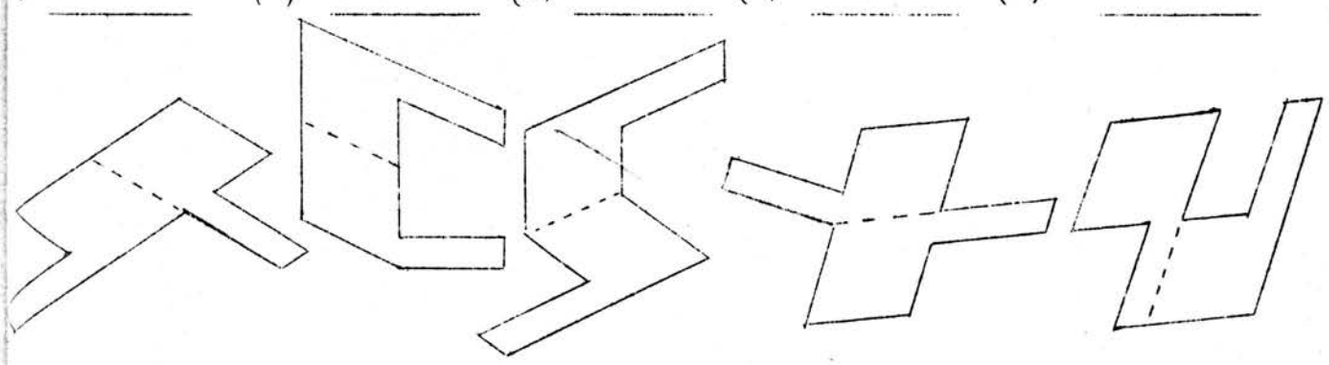
(1) _____ (2) _____ (3) _____ (4) _____ (5) _____



(6) _____ (7) _____ (8) _____ (9) _____ (10) _____

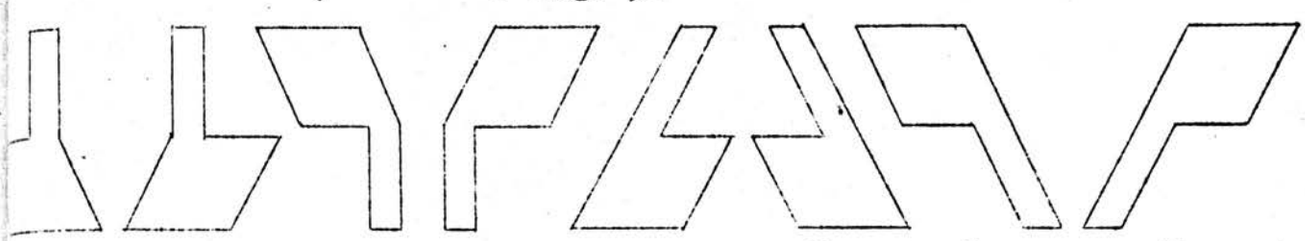


(11) _____ (12) _____ (13) _____ (14) _____ (15) _____

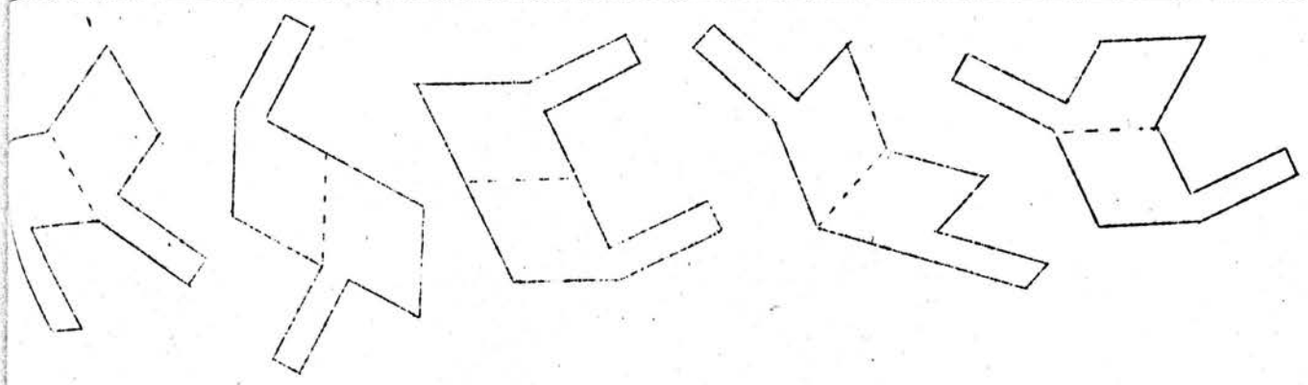


(16) _____ (17) _____ (18) _____ (19) _____ (20) _____

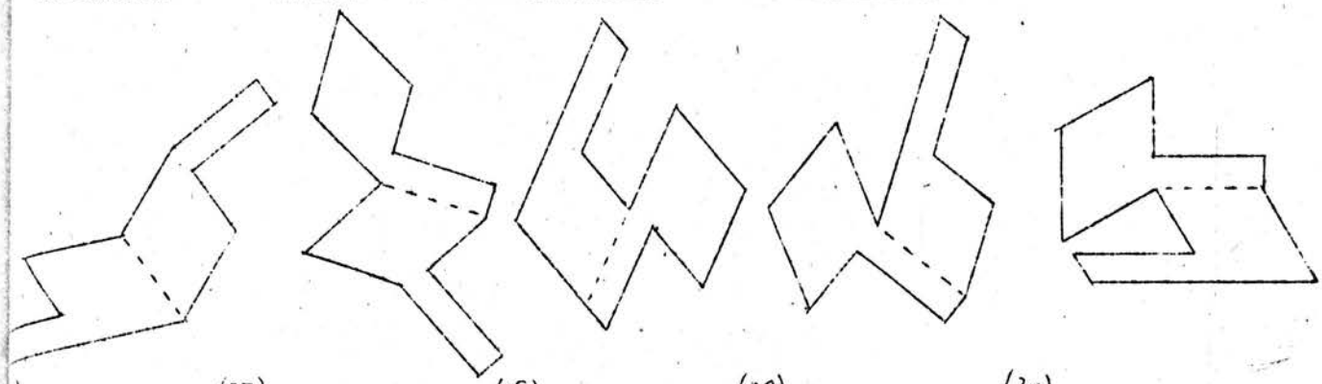
TURN OVER TO PAGE 3 WITHOUT WAITING TO BE TOLD.



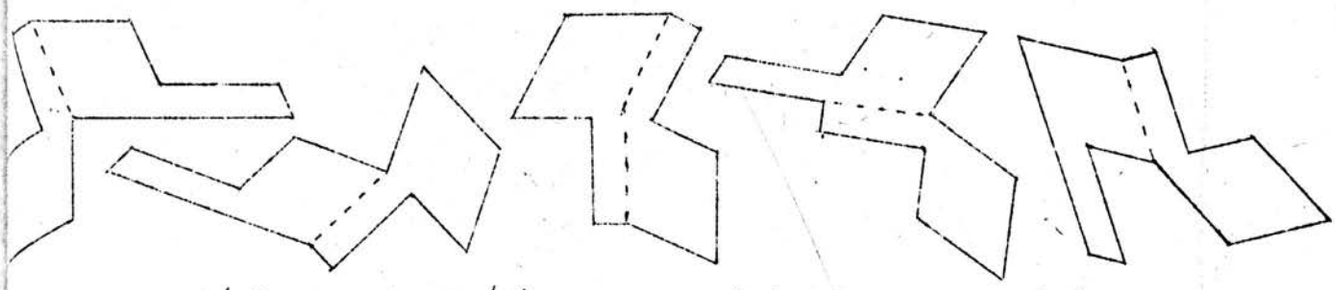
A B C D E F G H



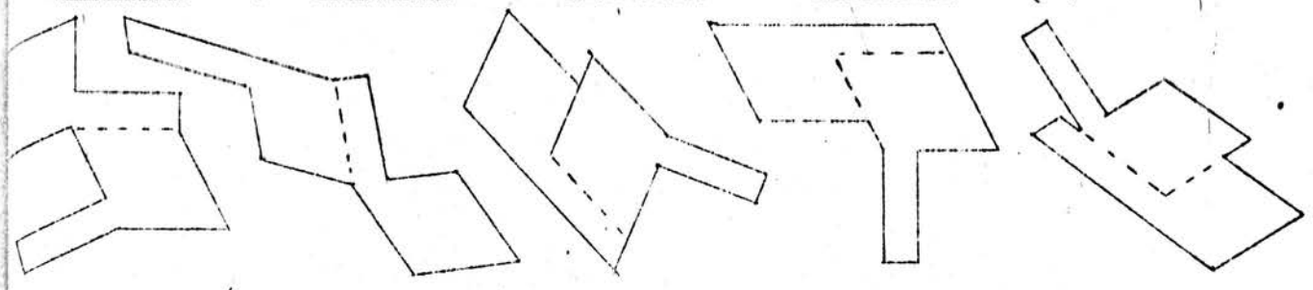
(22) (23) (24) (25)



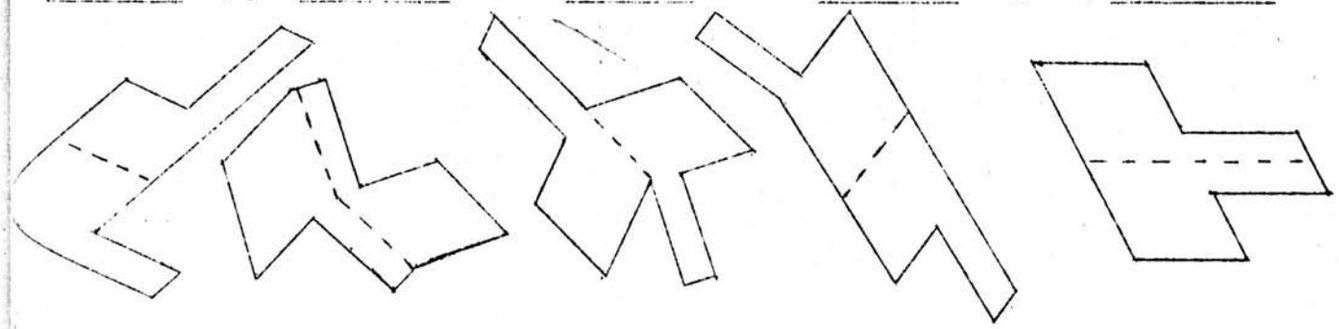
(27) (28) (29) (30)



(32) (33) (34) (35)



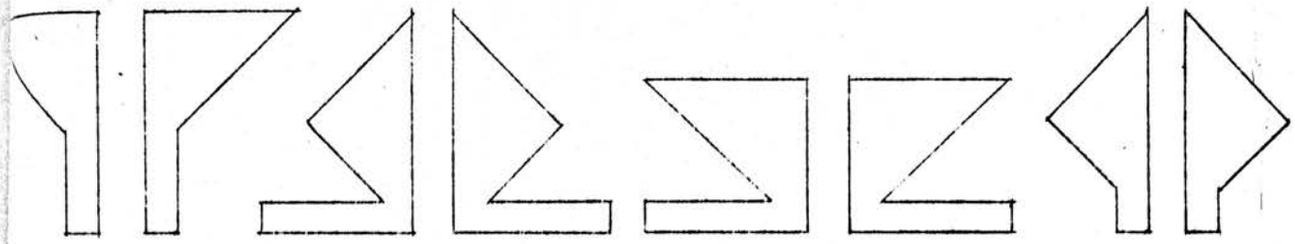
(37) (38) (39) (40)



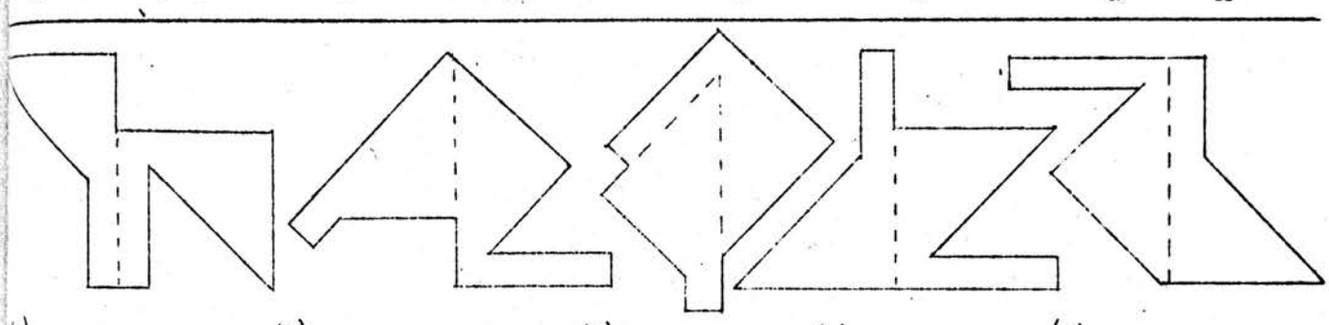
(42) (43) (44) (45)

TURN OVER TO PAGE 4 WITHOUT WAITING TO BE TOLD.

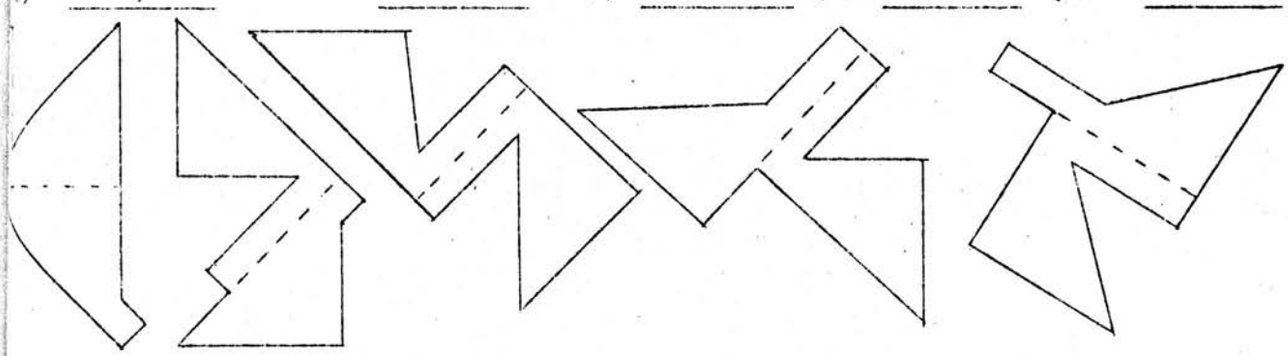
Do the questions below in the same way as those you have just done.



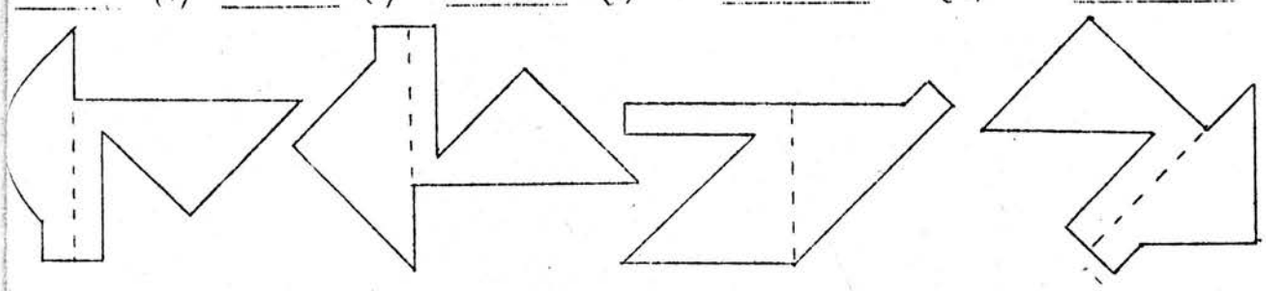
A B C D E F G H



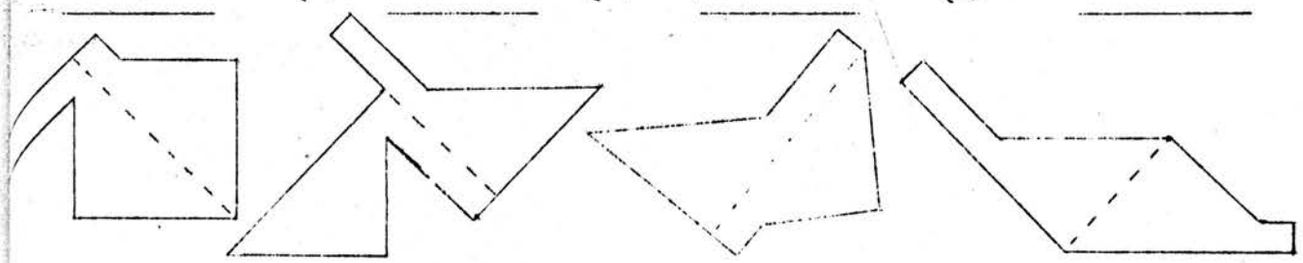
(1) (2) (3) (4) (5)



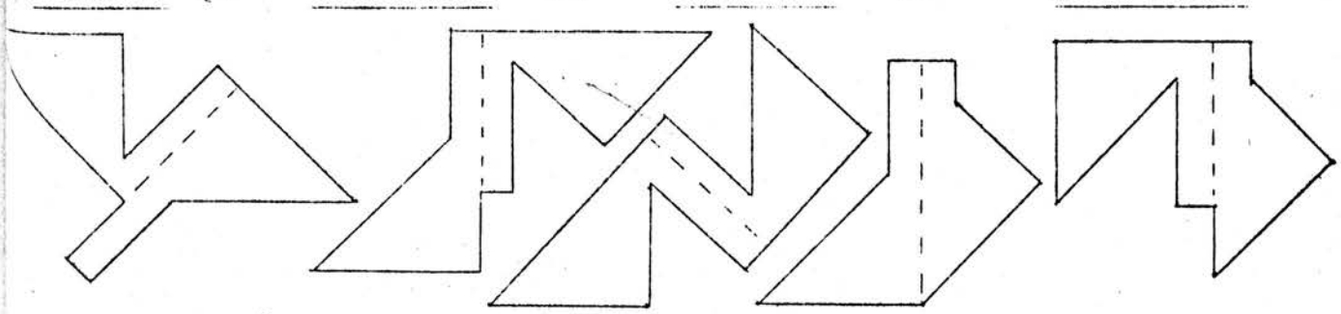
(7) (8) (9) (10)



(12) (13) (14)

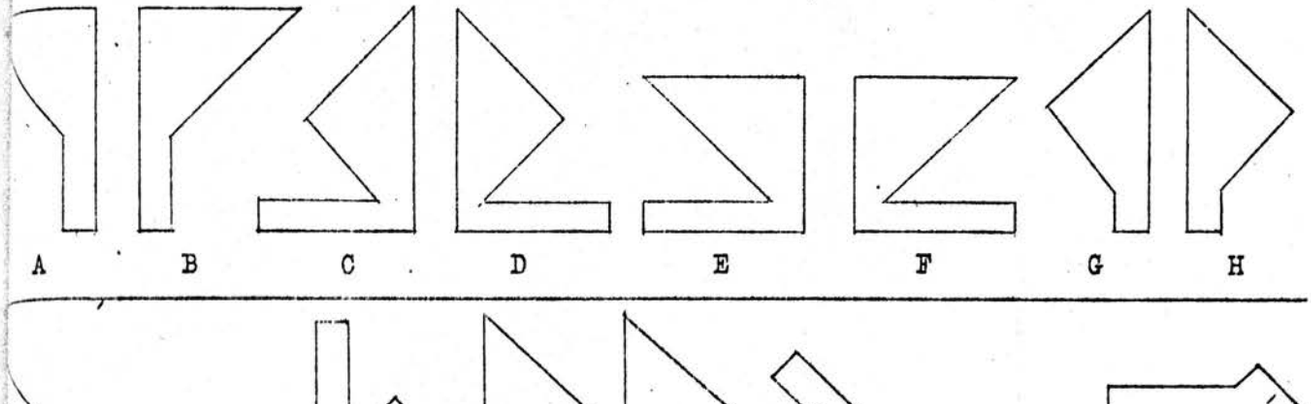


(16) (17) (18)

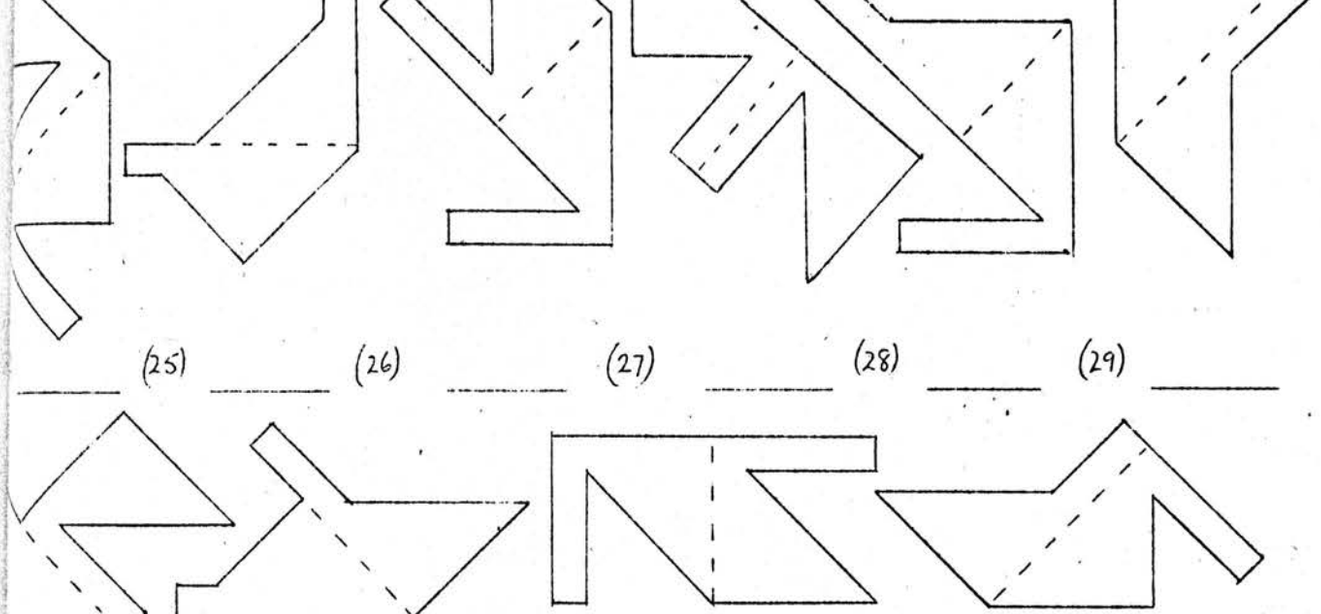


(20) (21) (22) (23)

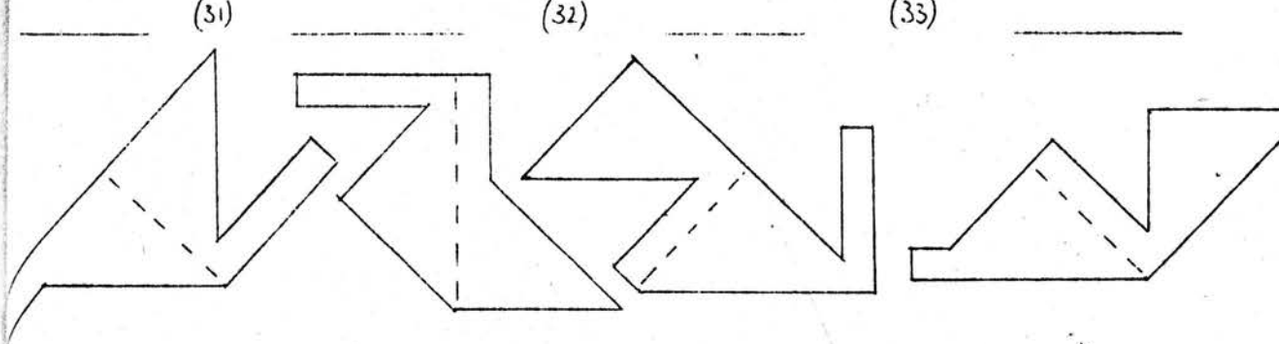
TURN OVER TO PAGE 5 WITHOUT WAITING TO BE TOLD.



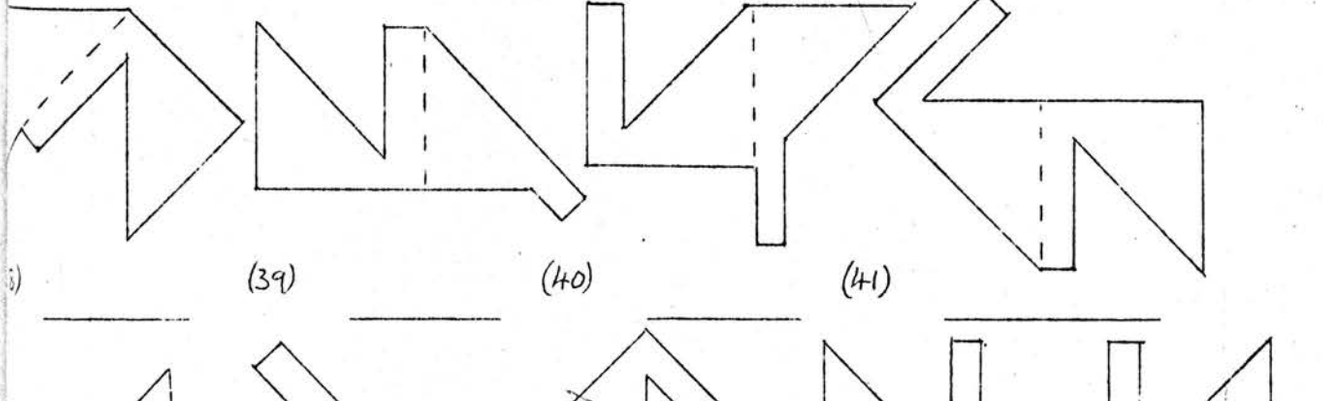
A B C D E F G H



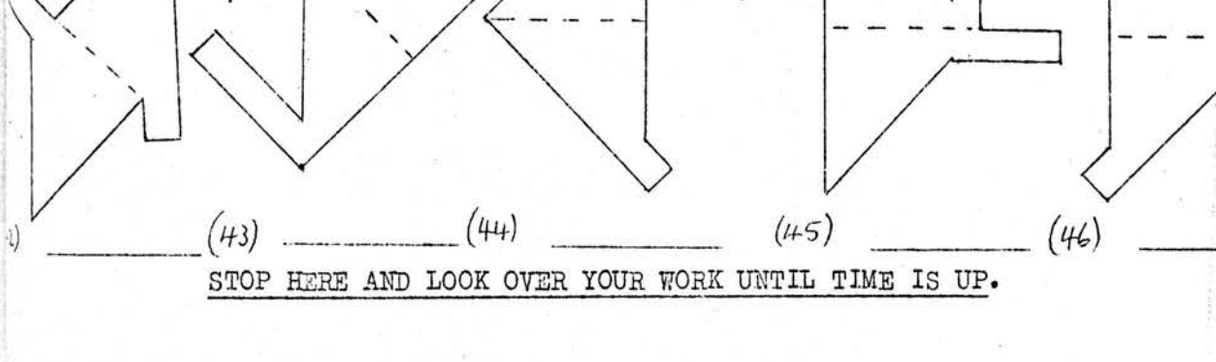
(25) _____ (26) _____ (27) _____ (28) _____ (29) _____



_____ (31) _____ (32) _____ (33) _____



34) _____ (35) _____ (36) _____ (37) _____



3) (39) (40) (41)

_____ _____ _____ _____

_____ (43) _____ (44) _____ (45) _____ (46) _____

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M O R A Y H O U S E E X P E R I M E N T A L

S P A C E T E S T 5/R

Not to be filled in by the Scholar	
Age in years and completed months y. m.	
Page	Score
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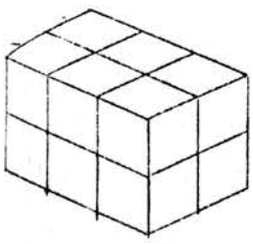
TOTAL	
Signature of Marker:	

Fill in the following particulars at once:-

1. Your Surname (In capital letters).....
2. Your Christian Name(s) (In capital letters).....
3. Sex (Boy or Girl).....
4. Name of your school.....
5. Class you are in.....
6. Your age.....years
7. Date of Your Birthday.....
8. Today's Date.....

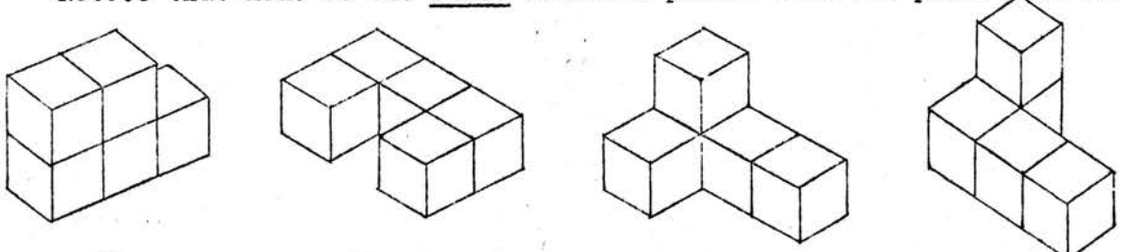


Look at the drawing at the top of the page.
It shows an oblong block made of small cubes.

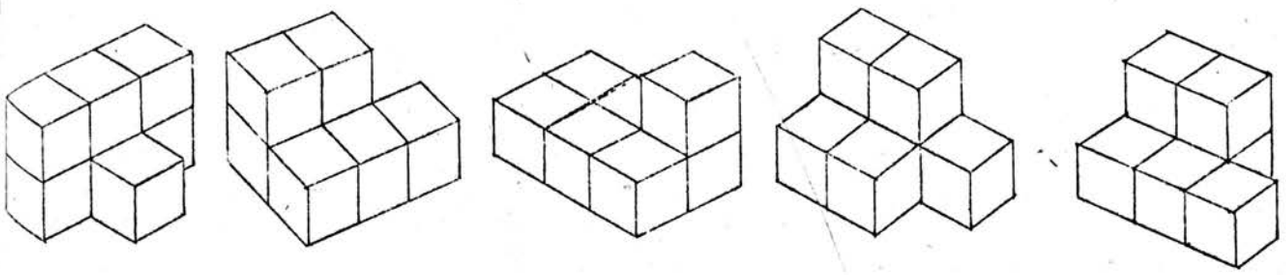
Now look at the drawings below. They show pieces of an oblong block like the one shown above.

Notice that the four pieces above the double line are lettered A, B, C and D while the five pieces below the double line are numbered 1, 2, 3, 4 and 5. You have to find out which of the lettered pieces will fit exactly each of the numbered pieces to make an oblong block like that at the top of the page. For example, piece B will fit exactly piece Number 1., and so we have written the letter B on the line underneath.

Notice that none of the other lettered pieces will fit piece No.1 exactly.



A B C D



1) B (2) _____ (3) _____ (4) _____ (5) _____

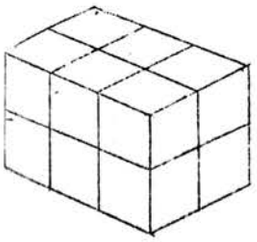
For each of the numbered pieces 2, 3, 4 and 5, write on the line underneath the letter of the piece needed to make an oblong block like that shown at the top of the page.

The pieces may be turned over into any position but they must fit exactly.

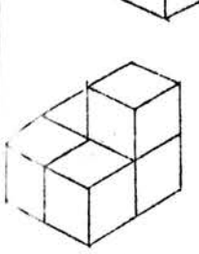
Now check your answers. They are:

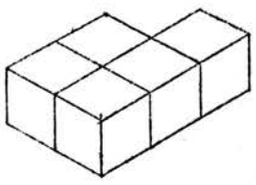
2. D 3. A 4. C 5. D

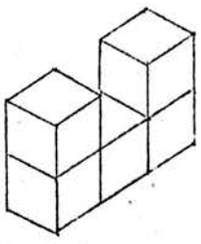
STOP HERE AND WAIT UNTIL YOU ARE TOLD TO BEGIN THE TEST.

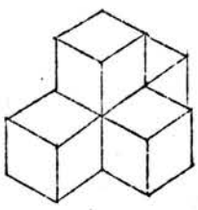


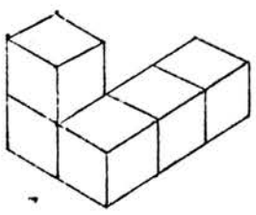
Now do the questions below in the same way as those you have just done. On the line under each question write the letter of the piece needed to make an oblong block like that shown at the top of the page. Remember the pieces can be turned over in to any position but they must fit <u>exactly</u>.


A


B


C


D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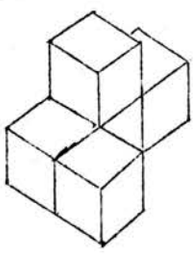
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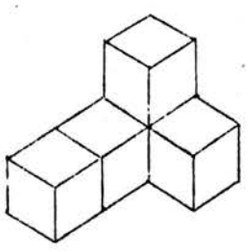
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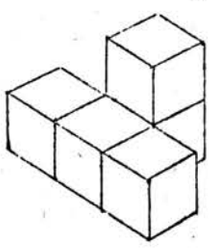
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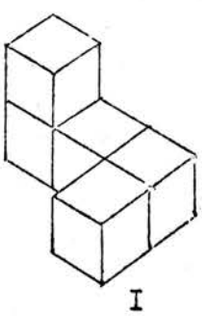
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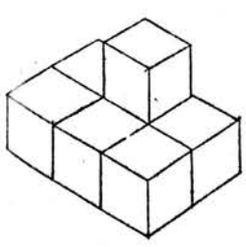
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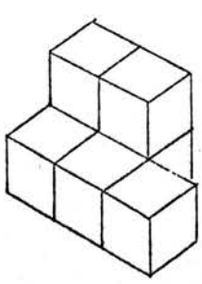
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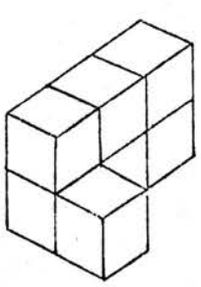
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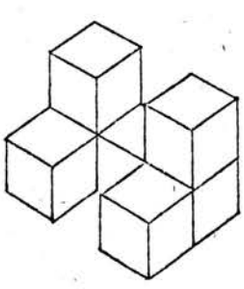
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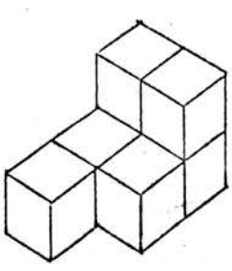
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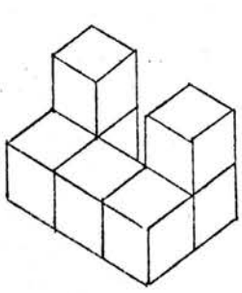
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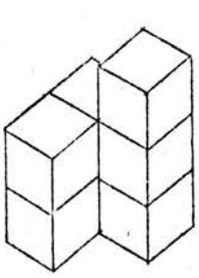
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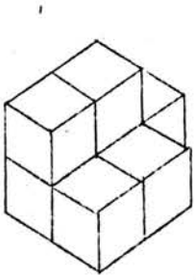
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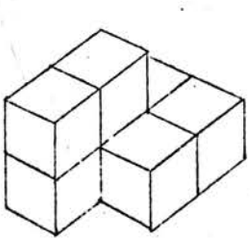
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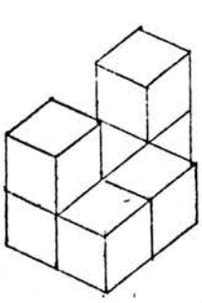
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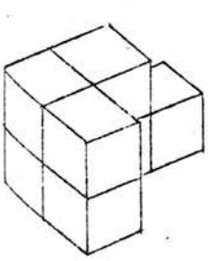
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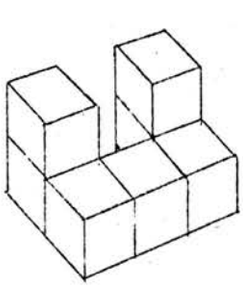
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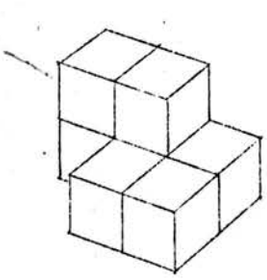
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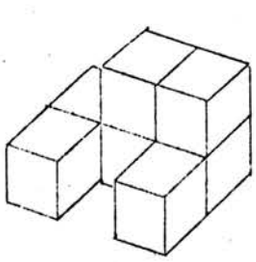
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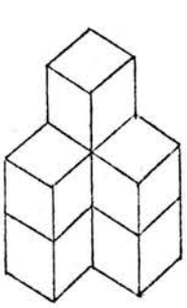
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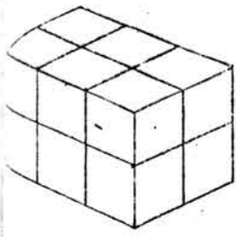

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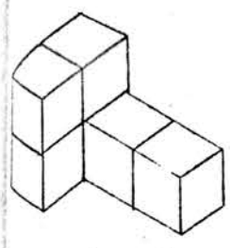

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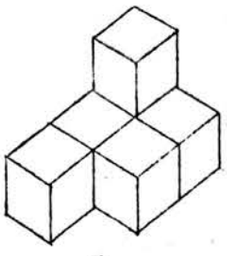

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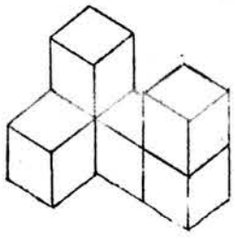

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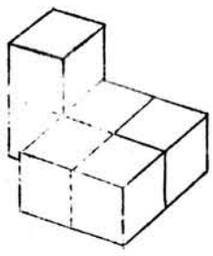

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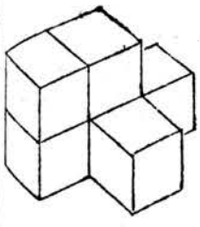

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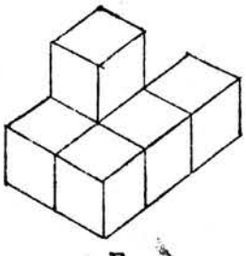

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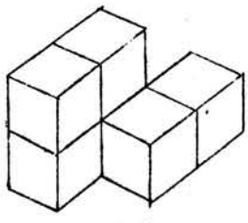

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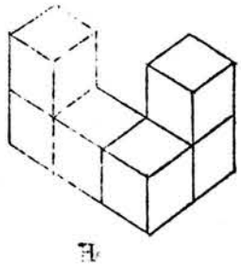

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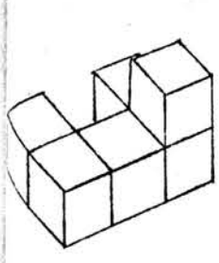

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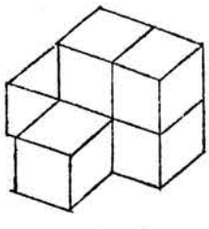

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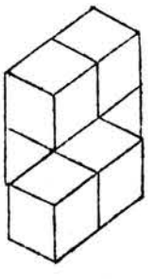

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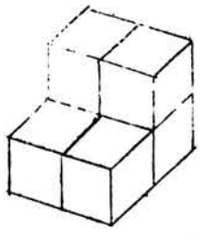

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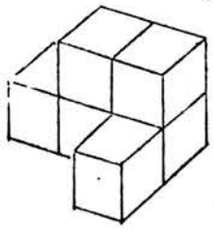

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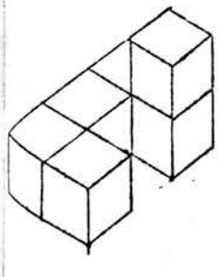

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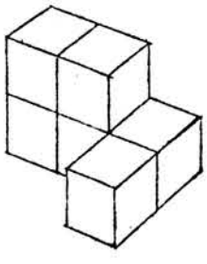

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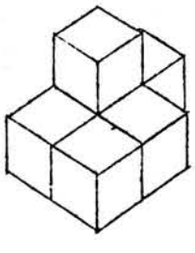

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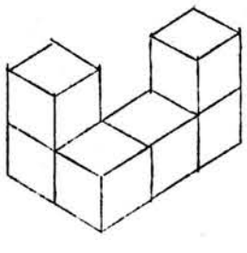

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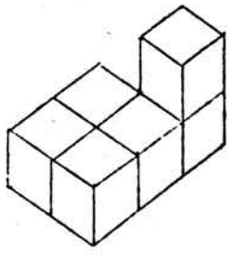

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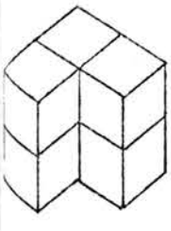

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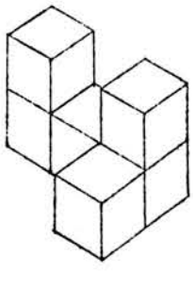

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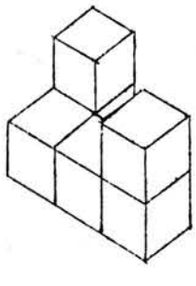

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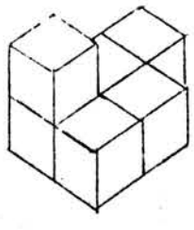

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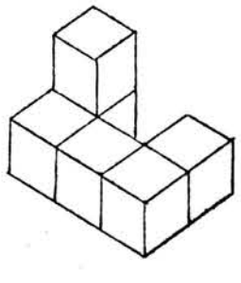

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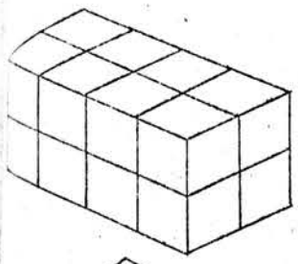
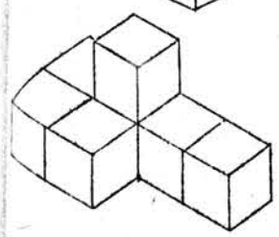
Do the questions below in the same way as those you have just done.





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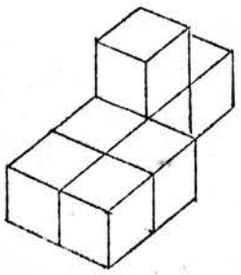

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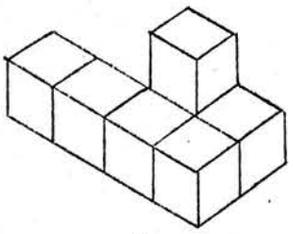

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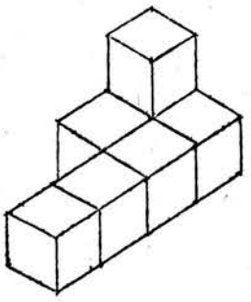

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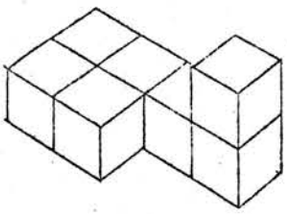

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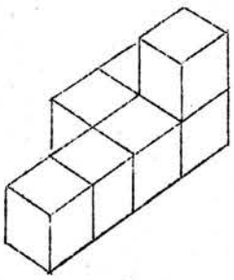

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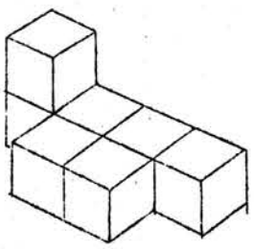

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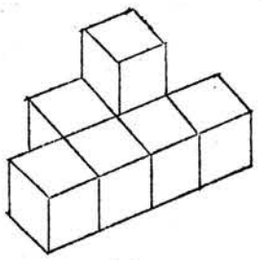

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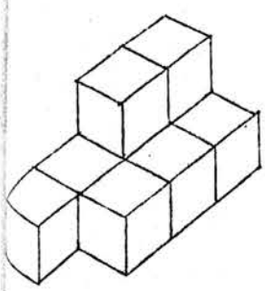

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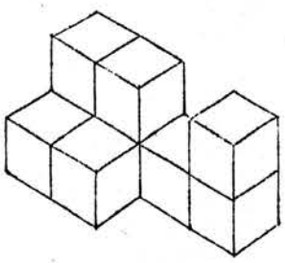

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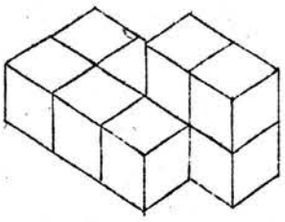

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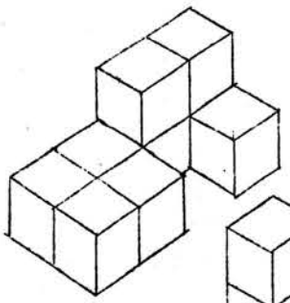

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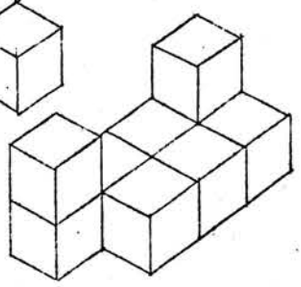

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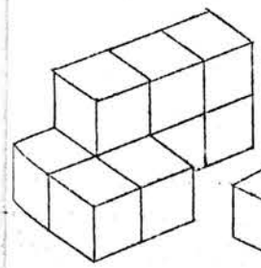

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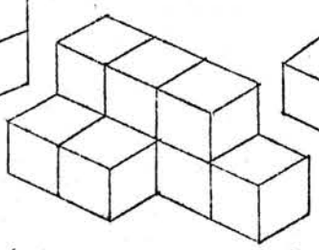

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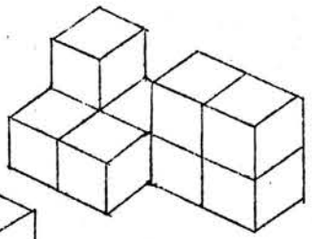

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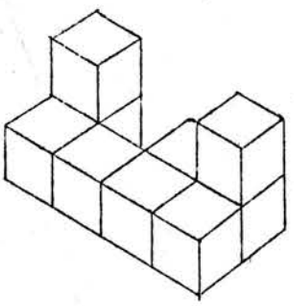

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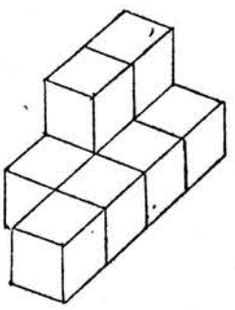

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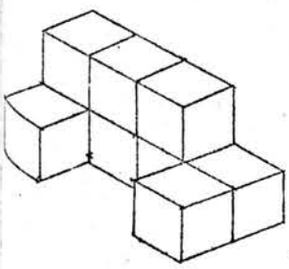

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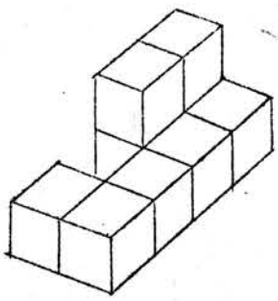

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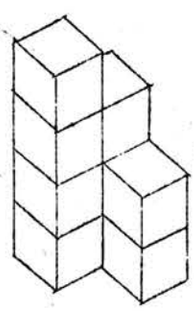

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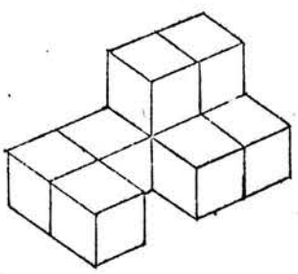

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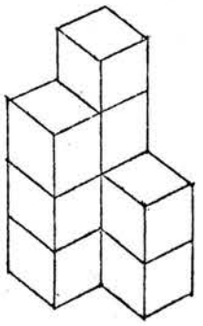

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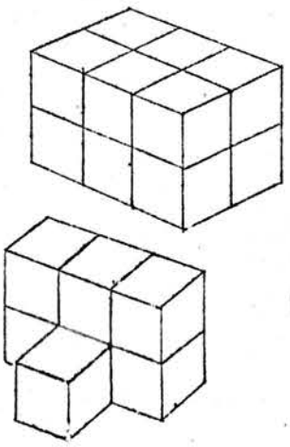
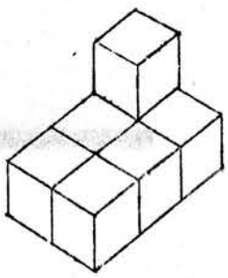


Do the questions below in the same way as those you have just done.

A



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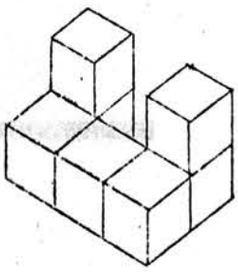

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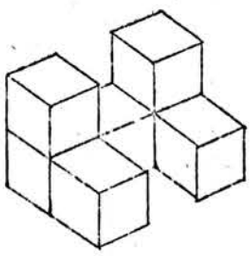

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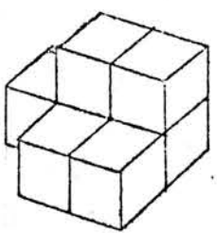

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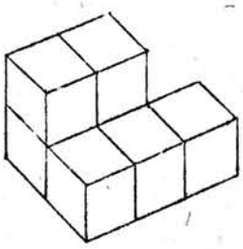

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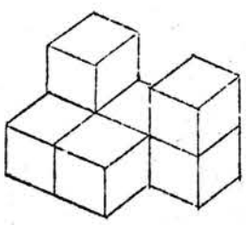

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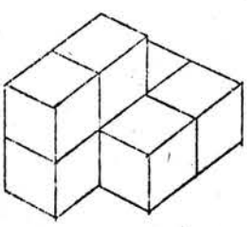

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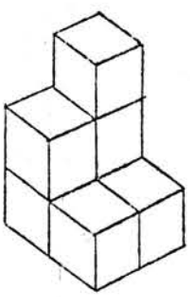

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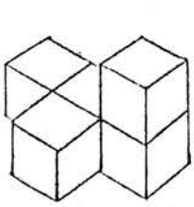

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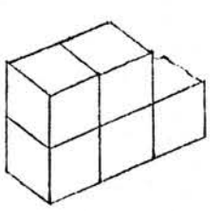

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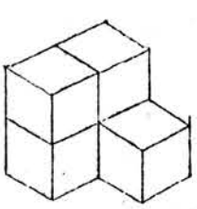

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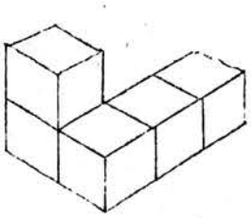

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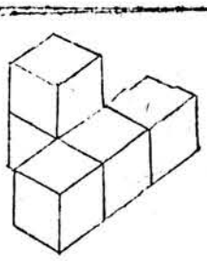

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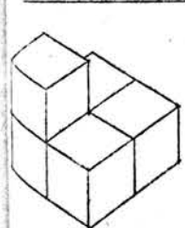

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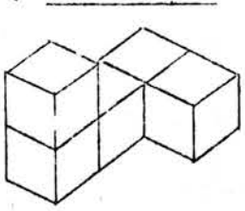

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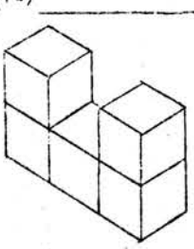

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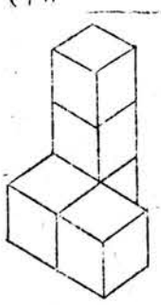

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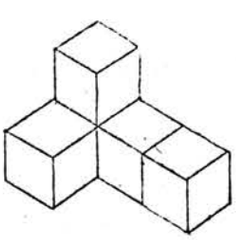

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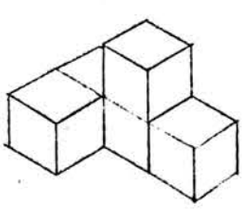

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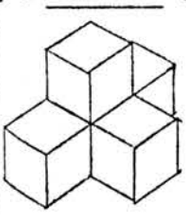

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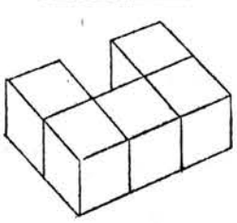

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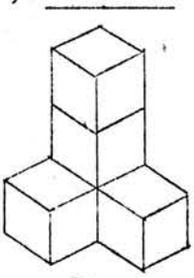

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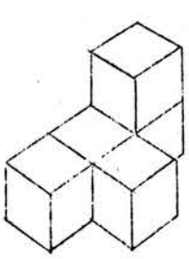

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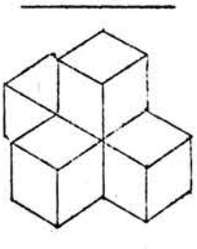

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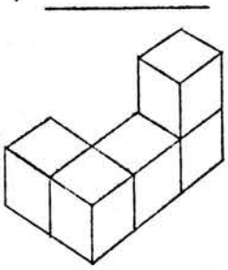

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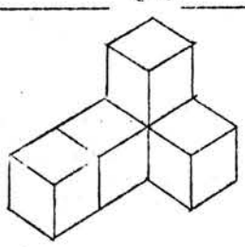

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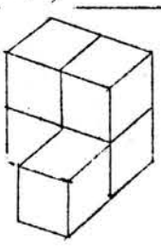

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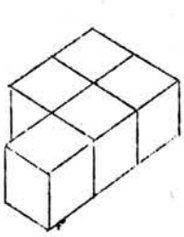

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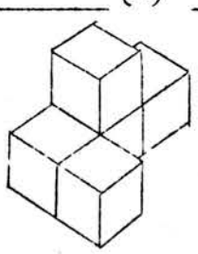

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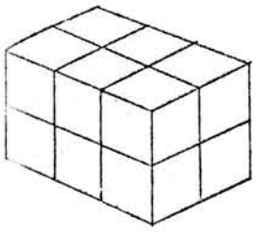
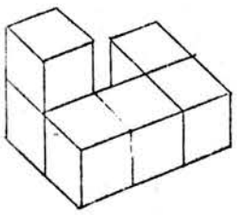


Do the questions below in the same way as those you have just done.



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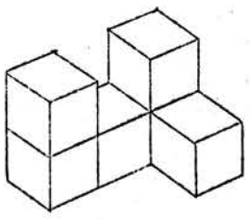

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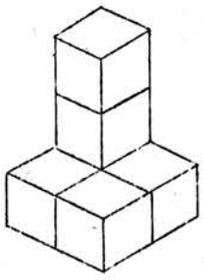

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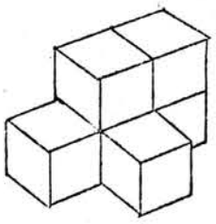

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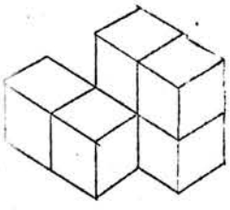

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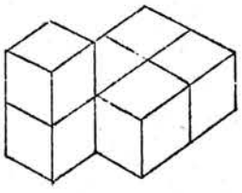

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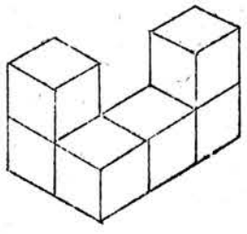

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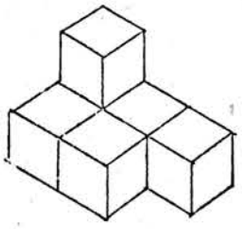

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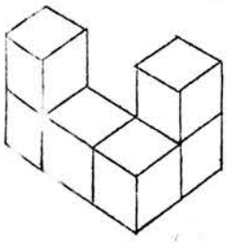

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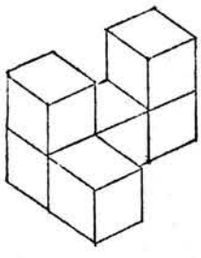

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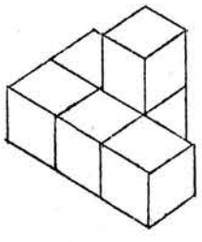

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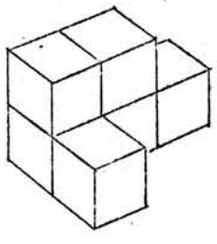

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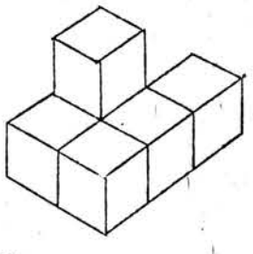

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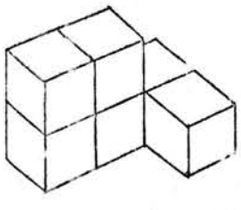

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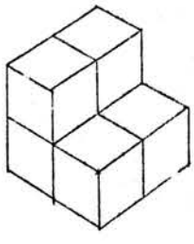

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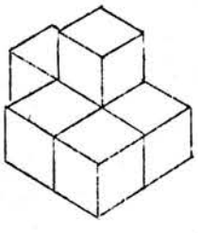

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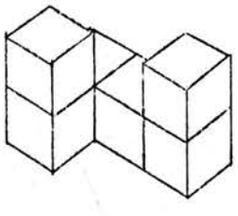
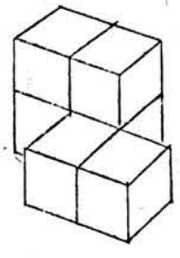
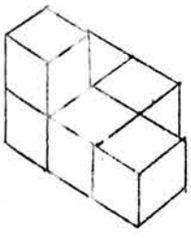


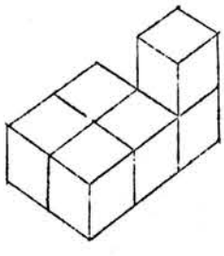
(75) _____



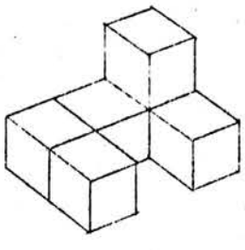
(76) _____



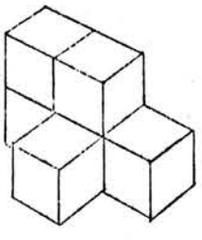
(77) _____



(78) _____



(79) _____



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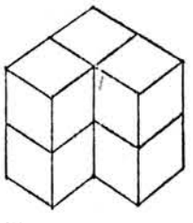
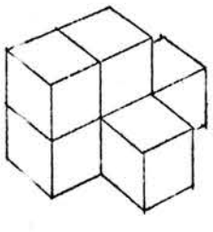
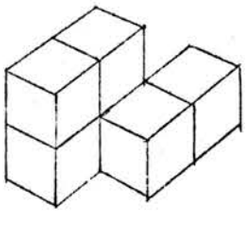


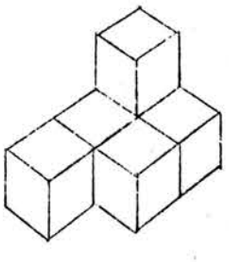
(81) _____



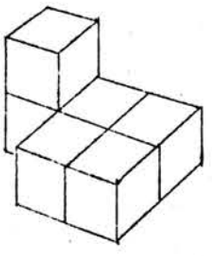
(82) _____



(83) _____



(84) _____



(85) _____

STOP HERE AND LOOK OVER YOUR WORK UNTIL TIME IS UP.

DO NOT TURN OVER OR OPEN THIS BOOK UNTIL YOU ARE TOLD.

M O R A Y H O U S E E X P E R I M E N T A L

S P A C E T E S T 6/R

Not to be filled in by the Scholar.	
Age in years and completed months y. m.	
Page	Score
2	
3	
TOTAL	
Signature of marker:	

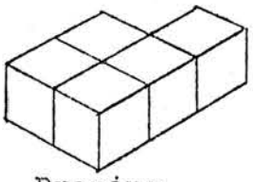
Fill in the following particulars at once:-

1. Your Surname (In capital letters).....
2. Your Christian Name(s) (In capital letters).....
3. Sex (Boy or Girl).....
4. Name of your school.....
5. Class you are in.....
6. Your Age.....years.
7. Date of Your Birthday.....
8. Today's Date.....

Look at drawing Number I below. It shows a cube. A cube has <u>six</u> sides or faces.

Now look at drawing Number 2. It shows a model which has been made by gluing together five cubes.

Drawing Number I.



Drawing Number 2.

1	2	3	4	5
0	1			

Suppose that the model in drawing Number 2 has been painted on all sides <u>except</u> the bottom. You have to find out how many cubes have paint on <u>one</u> face only; how many have paint on <u>two</u> faces only; and so on.

For example, in the above model, there are no cubes having paint on <u>one</u> face only, and so we have placed 0 in column one at the side of the model. There is one cube having paint on <u>two</u> faces and so we have placed 1 in column two at the side of the model.

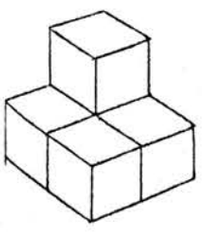
See if you can find out how many cubes there are having paint on <u>three</u> faces only. Write the answer in column three at the side of the model.

Now write in the answers for cubes having paint on <u>four</u> and on <u>five</u> faces.

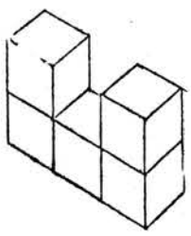
Check your answers. They are:-

1	2	3	4	5
0	1	3	1	0

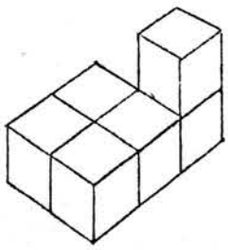
Do the same for the models shown in drawings 3, 4 and 5 below. Remember the models are painted on all sides <u>except</u> the bottom.



(3)



(4)



(5)

	1	2	3	4	5
(3)					
(4)					
(5)					

Check your answers. They are:-

	1	2	3	4	5
(3)	0	1	3	0	1
(4)	0	0	3	0	2
(5)	0	1	4	0	1

<u>Now read the following carefully</u>:-

1. All the questions in this test are like those you have just done.

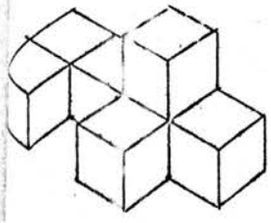
2. When you are told to begin turn over to page 2 and start working at once.

3. Work as quickly and as carefully as you can.

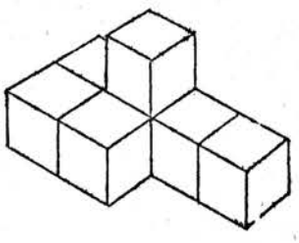
4. You will be allowed minutes.

<u>STOP HERE AND WAIT UNTIL YOU ARE TOLD TO BEGIN THE TEST.</u>

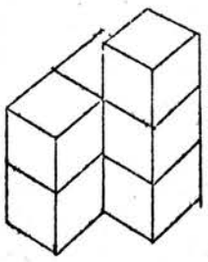
Do the questions below in the same way as those you have just done.



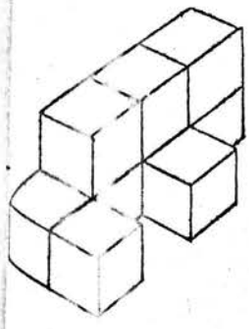
(19)



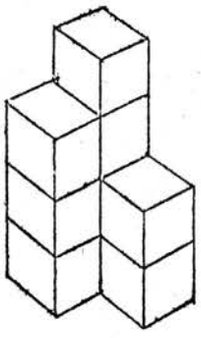
(20)



(21)



(22)



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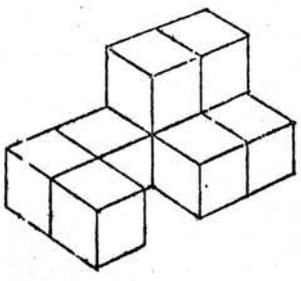
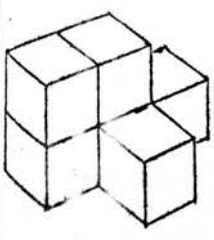
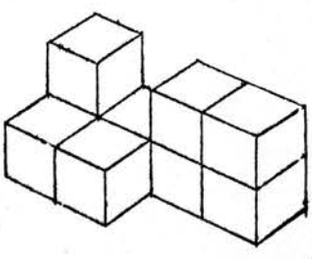


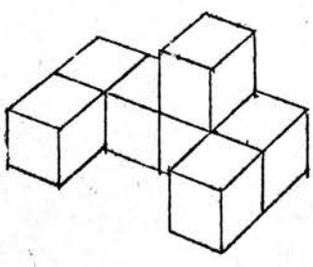
(24)



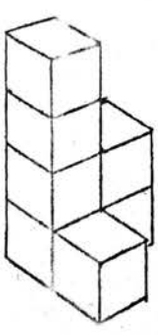
(25)



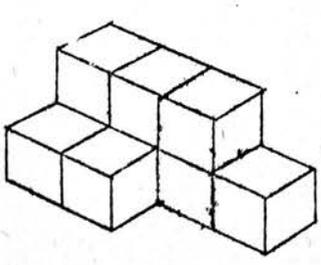
(26)



(27)



(28)



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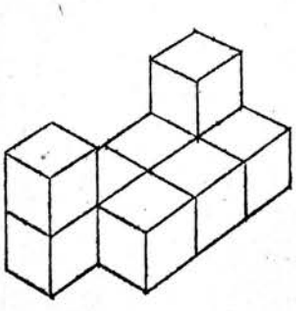

(30)

	1	2	3	4	5
(19)					
(20)					
(21)					
(22)					
(23)					
(24)					
(25)					
(26)					
(27)					
(28)					
(29)					
(30)					

STOP HERE AND
LOOK OVER YOUR WORK UNTIL TIME IS UP.

APPENDIX V

Answer Pattern Data.

Notes relating to the Answer Patterns.

Since there were no criterion scores for the group tested, the scripts were arranged in the order of total test-score.

Column S_1 relates to the scores of pupils in the top sixth of the group, S_2 to those in the second sixth and so on.

Column E_{13} gives the efficiency coefficient of each item, calculated from the formula:

$$E_{13} = \frac{S_1 + S_2 - S_5 - S_6}{n/3} ,$$

where n is the number in the group.

As a general rule, items answered by more than 80% or by less than 20% of the pupils were omitted in making up the final versions of the tests.. So, also, were items for which the efficiency coefficient was less than .45.

There are certain blank cells in the tables. These occur where it is clear from the information given, that the particular item will not satisfy one or other of the above requirements.

ANSWER PATTERN DATA for DRAFT VERSION of SPACE TEST 1/R.

(N = 108 - Two items per row).

Row	S_1	S_2	S_3	S_4	S_5	S_6	Σ	%	E_{13}	Revised Order.
1.	32	26	10	13	7	3	91	42	.67	29
2.	30	19	15	14	6	7	89	41	.50	31
3.	29	15	11	6	0	0	61	28	.61	40
4.	30	19	12	5	6	2	74	34	.57	37
5.	34	24	23	18	7	7	113	52	.61	7
6.	35	30.	26	16	6	7	120	56	.72	3
7.	34	25	19	13	5	4	100	46	.70	21
8.	25	19	21	14	7	3	89	41	.47	30
9.	34	26	22	14	7	5	108	50	.67	10
10.	34	29	22	13	7	4	109	50	.72	11
11.	32	26	18	10	3	1	90	42	.75	28
12.	35	32	26	16	9	5	123	57	.74	1
13.	34	24	23	6	5	6	98	45	.65	22
14.	31	18	7	3	2	5	66	30	.58	39
15.	36	28	20	11	8	3	106	49	.74	14
16.	34	30	24	10	3	2	103	48	.82	15
17.	36	33	14	9	8	4	104	48	.79	16
18.	35	23	17	12	5	2	94	43	.71	26
19.	33	26	19	15	6	0	99	46	.74	18
20.	34	25	14	17	4	6	100	46	.68	19
21.	33	28	7	8	7	5	88	41	.68	32
22.	33	31	25	6	2	4	101	47	.81	17
23.	33	29	31	17	7	6	123	57	.68	2
24.	36	33	22	16	3	4	114	53	.86	5
25.	32	27	23	9	7	1	99	46	.71	20
26.	36	35	19	14	5	4	113	52	.86	6
27.	36	29	19	12	5	5	106	49	.76	13
28.	24	15	10	8	5	2	64	30	.44	38
29.	32	26	19	8	8	3	96	44	.65	24
30.	29	30	19	7	6	4	95	44	.68	25
31.	33	30	23	14	5	4	109	50	.75	9
32.	30	23	21	11	3	6	94	43	.61	27
33.	34	26	12	11	13	2	98	45	.63	23
34.	32	31	18	24	10	4	119	55	.68	4
35.	28	20	10	7	8	4	77	36	.50	36
36.	32	30	23	14	8	5	112	52	.54	8
37.	24	23	15	8	6	6	82	38	.49	35
38.	34	24	16	9	0	3	86	40	.71	34
39.	32	24	10	15	4	3	88	41	.68	33
40.	29	27	26	15	9	3	109	50	.61	12

ANSWER PATTERN DATA for DRAFT VERSION of SPACE TEST 2/R.

(N = 78, and so 20% and 80% facility limits are 16 and 62).

Item	S_1	S_2	S_3	S_4	S_5	S_6	$\acute{z}$	E_{13}	Revised Order
1.	13	12	—	—	12	>6	—	<.45	Omit
2.	12	11	—	—	9	6	—	<.45	Omit
3.	13	13	13	10	6	5	60	.58	(3)
4.	13	10	10	7	5	3	48	.58	(44)
5.	13	13	10	9	4	3	52	.73	(26)
6.	13	13	—	—	8	7	—	<.45	Omit
7.	13	12	8	10	6	2	51	.65	(34)
8.	13	12	9	9	6	3	52	.62	(27)
9.	13	11	10	9	6	3	52	.58	(28)
10.	13	13	—	—	11	2	—	<.45	Omit
11.	11	8	—	—	7	1	—	<.45	Omit
12.	13	12	13	12	7	3	60	.58	(4)
13.	12	10	11	4	4	1	42	.65	(60)
14.	13	10	9	7	3	1	43	.73	(55)
15.	13	10	8	8	4	1	44	.69	(53)
16.	12	12	9	8	9	1	51	.54	(35)
17.	13	12	10	8	8	1	52	.62	(29)
18.	13	13	11	12	9	2	60	.58	(5)
19.	12	13	12	8	10	0	55	.58	(16)
20.	13	11	—	—	9	4	—	<.45	Omit
21.	13	11	13	10	7	4	58	.50	(8)
22.	10	11	7	6	1	2	37	.69	(73)
23.	12	13	13	9	6	4	57	.58	(11)
24.	13	11	13	12	9	3	61	.46	(1)
25.	13	12	11	11	7	5	59	.50	(6)
26.	13	13	—	—	11	4	—	<.45	Omit
27.	12	13	10	9	8	3	55	.54	(17)
28.	12	12	10	10	10	2	56	.46	(13)
29.	12	12	13	10	8	2	57	.54	(12)
30.	13	12	—	—	10	4	—	<.45	Omit
31.	12	10	7	5	3	4	41	.50	(63)
32.	13	12	12	9	5	2	53	.69	(23)
33.	13	12	12	8	4	1	50	.77	(37)
34.	12	12	12	10	6	3	55	.58	(18)
35.	12	12	7	10	3	1	45	.77	(52)
36.	13	10	9	7	6	2	47	.58	(46)
37.	11	10	11	7	3	4	46	.54	(50)
38.	13	12	11	10	6	2	54	.65	(21)
39.	13	12	13	11	11	2	62	<.45	Omit
40.	13	11	5	7	2	4	42	.69	(61)
41.	13	13	11	12	7	3	59	.62	(7)
42.	12	11	9	11	2	2	47	.73	(47)
42(a)	13	13	11	11	4	3	55	.73	(19)
43.	12	10	10	9	4	2	47	.69	(48)
44.	13	12	12	8	6	1	52	.69	(30)
45.	13	12	8	11	9	3	56	.50	(14)
46.	12	12	11	10	4	3	52	.65	(31)
47.	13	7	9	5	4	0	38	.62	(71)
48.	13	12	10	9	8	3	55	.54	(20)
49.	13	13	11	7	8	1	53	.65	(24)
50.	13	12	10	12	7	2	56	.62	(15)
51.	13	11	10	8	3	2	47	.73	(49)
52.	13	11	11	9	4	2	50	.69	(38)
53.	13	13	—	—	9	4	—	<.45	Omit
54.	13	13	13	11	7	4	61	.58	(2)

Item	S_1	S_2	S_3	S_4	S_5	S_6	Σ	E_{13}	Revised Order
55.	13	10	11	10	5	1	50	.65	(39)
56.	12	10	10	7	3	1	43	.69	(56)
57.	13	11	11	5	1	2	43	.81	(57)
58.	13	13	11	9	6	0	52	.77	(32)
59.	12	13	12	11	5	5	58	.58	(9)
60.	13	11	–	–	10	4	–	<.45	Omit
61.	12	12	–	–	10	5	–	<.45	Omit
62.	11	13	9	4	2	1	40	.81	(66)
63.	12	12	9	8	4	1	46	.73	(51)
64.	12	11	13	9	4	2	51	.65	(36)
65.	13	13	13	12	9	2	>62	.58	Omit
66.	13	11	10	12	3	0	49	.81	(42)
67.	12	12	12	8	7	2	53	.58	(25)
68.	13	11	6	5	4	2	41	.69	(64)
69.	13	11	12	6	4	2	48	.69	(44)
70.	13	11	9	5	4	1	43	.73	(58)
71.	13	12	10	4	4	1	44	.78	(54)
72.	13	13	11	8	5	0	50	.81	(40)
73.	13	12	12	9	6	2	54	.65	(22)
74.	13	13	11	12	7	2	58	.65	(10)
75.	13	11	10	10	2	3	49	.73	(43)
76.	13	5	7	3	3	0	31	.58	(85)
77.	12	10	7	5	3	0	37	.73	(74)
78.	12	8	7	5	4	2	38	.54	(72)
79.	13	10	8	3	3	0	37	.78	(75)
80.	13	10	9	4	2	1	39	.78	(68)
81.	12	13	8	6	1	1	41	.88	(65)
82.	12	9	6	4	2	1	34	.69	(81)
83.	12	10	8	5	0	0	35	.85	(80)
84.	11	9	11	5	2	1	39	.65	(69)
85.	12	10	7	4	3	1	37	.69	(76)
86.	13	9	8	5	1	4	40	.65	(67)
87.	13	10	5	3	0	1	32	.85	(84)
88.	13	11	12	9	4	3	52	.65	(33)
89.	13	12	8	2	0	2	37	.88	(77)
90.	13	12	10	5	1	2	43	.85	(59)
91.	13	10	9	1	1	2	36	.77	(78)
92.	12	10	9	3	0	0	34	.85	(82)
93.	13	9	10	4	0	0	36	.85	(79)
94.	10	10	5	4	3	2	34	.58	(83)
95.	11	10	12	3	1	2	39	.69	(70)
96.	11	11	10	9	0	1	42	.80	(62)
97.	12	9	8	1	0	0	30	.80	(86)
98.	13	10	12	8	3	4	50	.61	(41)

ANSWER PATTERN DATA for DRAFT VERSION of SPACE TEST 3/R.

(N = 42).

Item	S_1	S_2	S_3	S_4	S_5	S_6	Σ	%	E_{13}	Revised Order.
Part I.										
1.	5	6	–	–	6	6	–	–	<.45	Omit
2.	6	6	4	4	3	1	24	57	.57	(41)
3.	5	5	2	2	0	2	16	38	.57	(54)
4.	4	3	–	–	2	3	–	–	<.45	Omit
5.	6	4	–	–	3	3	–	–	<.45	Omit
6.	7	6	–	–	6	4	–	–	<.45	Omit
7.	3	3	–	–	1	1	–	–	<.45	Omit
8.	3	4	3	1	0	0	11	26	.50	(62)
9.	3	3	–	–	2	1	–	–	<.45	Omit
10.	5	2	–	–	3	0	–	–	<.45	Omit
11.	6	2	4	0	1	0	13	31	.50	(61)
12.	1	6	–	–	1	2	–	–	<.45	Omit
13.	6	2	–	–	2	1	–	–	<.45	Omit
14.	5	4	–	–	2	3	–	–	<.45	Omit
15.	4	2	–	–	–	–	–	–	<.45	Omit
16.	5	2	–	–	4	1	–	–	<.45	Omit
17.	2	1	–	–	–	–	–	–	<.45	Omit
18.	6	3	3	1	1	1	15	36	.50	(56)
19.	4	6	5	0	2	1	18	43	.50	(45)
20.	1	2	–	–	–	–	–	–	<.45	Omit
21.	7	3	3	0	2	1	16	38	.50	(55)
22.	6	5	2	2	3	1	19	45	.50	(44)
23.	6	6	4	2	1	2	21	50	.64	(43)
24.	1	4	–	–	–	–	–	–	<.45	Omit
25.	5	2	–	–	4	–	–	–	<.45	Omit
26.	4	4	3	3	1	0	15	36	.50	(57)
27.	6	4	2	1	1	1	15	36	.57	(58)
28.	4	3	–	–	1	1	–	–	.45	Omit
29.	7	4	1	5	1	0	18	43	.71	(46)
30.	7	5	2	2	1	1	18	43	.71	(47)
31.	5	5	2	1	0	1	14	33	.64	(59)
32.	0	5	–	–	2	–	–	–	<.45	Omit
33.	4	2	–	–	1	–	–	–	<.45	Omit
34.	5	6	–	–	4	2	–	–	<.45	Omit
35.	5	4	5	2	1	0	17	40	.57	(49)
36.	7	6	4	5	0	4	26	62	.64	(40)
37.	4	3	–	–	1	1	–	–	<.45	Omit
38.	7	5	0	2	2	2	18	43	.57	(48)
39.	7	5	2	0	1	2	17	40	.64	(50)
40.	6	3	4	2	1	1	17	40	.50	(51)
41.	7	4	4	2	0	0	17	40	.78	(52)
42.	5	5	1	0	1	0	12	39	.64	(53)
43.	4	4	3	2	1	0	14	33	.50	(60)
44.	7	6	2	2	5	1	23	55	.50	(42)
45.	3	0	–	–	1	0	–	–	–	Omit
Part II										
1.	4	5	4	1	0	1	15	36	.57	(39)
2.	7	5	4	4	0	1	21	50	.79	(25)
3.	5	4	4	2	0	2	17	40	.50	(37)
4.	7	5	2	3	2	0	19	45	.71	(31)
5.	7	5	3	5	1	0	21	50	.79	(26)
6.	6	6	2	2	4	0	20	48	.57	(29)
7.	7	4	–	–	5	3	–	–	–	Omit

Item	S_1	S_2	S_3	S_4	S_5	S_6	Σ	%	E_{13}	Revised Order.
8.	7	4	4	3	2	1	21	50	.57	(27)
9.	5	4	5	2	3	0	19	45	.43	(32)
10.	7	4	6	5	1	0	23	55	.71	(23)
11.	7	5	7	5	2	2	28	67	.57	(5)
12.	7	6	3	6	2	2	26	62	.64	(9)
13.	7	5	–	–	5	3	–	–	–	Omit
14.	7	6	5	4	1	1	24	57	.79	(18)
15.	7	7	5	5	3	0	27	64	.79	(8)
16.	7	6	4	5	4	0	26	62	.64	(10)
17.	7	6	5	3	4	1	26	62	.57	(11)
18.	7	7	4	5	6	2	31	74	.43	(1)
19.	7	6	4	3	3	3	26	62	.50	(12)
20.	7	6	3	4	0	0	20	48	.93	(30)
21.	6	5	4	2	2	0	19	45	.64	(33)
22.	5	5	4	6	2	2	24	57	.43	(19)
23.	6	6	–	–	6	1	–	–	–	Omit
24.	6	5	–	–	6	2	–	–	–	Omit
25.	7	6	6	5	3	1	28	67	.64	(6)
26.	7	5	5	0	1	1	19	45	.71	(34)
27.	6	2	4	3	3	0	18	43	.36	(35)
28.	7	6	4	3	4	1	25	60	.57	(15)
29.	6	7	–	–	5	4	–	–	–	Omit
30.	6	6	5	7	3	2	29	69	.50	(3)
31.	7	7	3	5	1	1	24	57	.86	(20)
32.	6	6	–	–	4	4	–	–	–	Omit
33.	7	7	5	2	3	0	24	57	.79	(21)
34.	7	4	4	4	2	1	22	52	.57	(24)
35.	6	7	5	4	3	0	25	60	.71	(16)
36.	7	3	4	2	3	2	21	50	.36	(28)
37.	7	6	5	5	5	0	28	67	.57	(7)
38.	7	6	4	4	2	1	24	57	.71	(22)
39.	7	7	6	5	4	2	31	74	.57	(2)
40.	7	7	5	4	3	3	29	69	.57	(4)
41.	4	4	–	–	2	1	–	–	–	Omit
42.	7	7	5	4	2	1	26	62	.79	(13)
43.	7	6	3	4	2	3	25	60	.57	(17)
44.	4	6	2	2	2	0	16	38	.57	(38)
45.	7	5	3	3	0	0	18	43	.86	(36)
46.	7	5	5	4	3	2	26	62	.50	(14)

ANSWER PATTERN DATA for DRAFT VERSION of SPACE TEST 5/R.

(N = 120).

Item	S_1	S_2	S_3	S_4	S_5	S_6	£	%	E_{13}	Revised Order.
1.	18	15	-	-	15	9	-	-	-	Omit
2.	19	13	13	13	10	8	76	63	.35	2
3.	14	16	13	12	4	1	60	50	.63	9
4.	16	8	16	13	6	4	63	53	.35	8
5.	10	6	-	-	4	4	-	-	-	Omit
6.	17	12	17	16	7	7	76	63	.38	3
7.	10	12	10	4	6	2	44	37	.35	11
8.	15	11	9	13	4	1	53	44	.53	10
9.	18	13	14	13	8	5	71	59	.45	6
10.	8	1	-	-	-	-	-	-	-	Omit
11.	5	4	-	-	-	-	-	-	-	Omit
12.	16	16	16	17	5	3	73	61	.60	5
13.	16	13	12	12	5	5	63	53	.48	7
14.	10	4	-	-	-	-	-	-	-	Omit
15.	10	6	-	-	3	0	-	-	.33	Omit
16.	12	10	16	8	3	4	53	44	.38	17
17.	18	14	13	11	7	5	68	57	.50	15
18.	14	13	14	12	8	7	68	57	.30	16
19.	4	3	-	-	-	-	-	-	-	Omit
20.	5	3	-	-	-	-	-	-	-	Omit
21.	16	8	9	10	1	0	44	37	.58	18
22.	2	5	-	-	-	-	-	-	-	Omit
23.	5	4	-	-	-	-	-	-	-	Omit
24.	9	7	5	3	3	1	28	23	.30	21
25.	15	15	12	16	8	9	75	63	.33	14
26.	11	9	-	-	6	3	-	-	.28	Omit
27.	8	5	-	-	-	-	-	-	-	Omit
28.	8	3	-	-	-	-	-	-	-	Omit
29.	11	6	7	3	1	0	30	25	.43	19
30.	14	9	6	6	1	0	36	30	.55	20
31.	13	10	10	7	3	2	45	38	.45	52
32.	10	3	-	-	-	-	-	-	-	Omit
33.	11	5	7	5	4	0	32	27	.30	54
34.	18	12	10	6	2	5	53	44	.58	51
35.	17	9	6	3	3	3	41	34	.50	53
36.	8	6	-	-	4	-	-	-	-	Omit
37.	8	5	-	-	-	-	-	-	-	Omit
38.	5	2	-	-	-	-	-	-	-	Omit
39.	10	7	3	5	5	0	30	25	.30	55
40.	9	9	4	4	3	1	30	25	.35	56
41.	9	5	-	-	-	-	-	-	-	Omit
42.	7	11	3	4	2	2	29	24	.35	58
43.	7	11	5	3	0	1	27	23	.43	59
44.	11	10	3	3	2	1	30	25	.45	57
45.	2	7	-	-	-	-	-	-	-	Omit
46.	15	12	5	5	3	2	42	35	.55	29
47.	14	15	9	5	3	2	48	40	.60	27
48.	6	2	-	-	-	-	-	-	-	Omit
49.	16	15	9	5	3	3	51	43	.63	26
50.	16	15	10	9	8	4	62	52	.48	24
51.	2	2	-	-	-	-	-	-	-	Omit
52.	5	3	-	-	-	-	-	-	-	Omit
53.	20	8	11	6	7	2	54	45	.48	25
54.	13	5	2	0	2	0	22	18	.40	32
55.	11	7	3	2	1	0	24	20	.43	30

Item	S_1	S_2	S_3	S_4	S_5	S_6	Σ	%	E_{13}	Revised Order.
56.	7	5	–	–	–	–	–	–	–	Omit
57.	12	9	8	1	0	0	30	25	.53	35
58.	13	10	10	5	5	4	47	39	.35	31
59.	6	5	–	–	–	–	–	–	–	Omit
60.	10	7	4	2	2	1	26	22	.35	34
61.	13	8	5	3	2	1	32	27	.45	28
62.	7	2	–	–	–	–	–	–	–	Omit
63.	9	7	3	2	3	0	24	20	.33	36
64.	5	5	–	–	–	–	–	–	–	Omit
65.	14	12	8	4	1	0	39	33	.63	33
66.	8	3	–	–	–	–	–	–	–	Omit
67.	11	8	5	7	6	1	38	32	.30	42
68.	11	7	6	3	4	2	33	28	.30	46
69.	14	8	5	8	7	1	43	36	.35	38
70.	12	7	8	5	6	1	39	33	.30	Omit
71.	12	8	6	3	2	1	32	27	.43	48
72.	11	8	3	4	3	1	31	26	.40	49
73.	7	4	–	–	–	–	–	–	–	Omit
74.	7	4	–	–	–	–	–	–	–	Omit
75.	8	–	–	–	–	–	–	–	–	Omit
76.	7	–	–	–	–	–	–	–	–	Omit
77.	11	10	6	4	0	1	32	27	.50	47
78.	13	12	8	4	2	2	41	34	.53	39
79.	10	8	5	6	5	1	35	29	.30	45
80.	11	6	4	4	0	1	26	22	.40	50
81.	11	9	8	6	3	2	39	33	.38	41
82.	9	10	7	6	5	2	39	33	.30	40
83.	10	9	7	5	3	1	35	29	.38	44
84.	8	10	9	6	2	1	36	30	.38	43
85.	16	7	10	9	1	0	43	36	.55	37

ANSWER PATTERN DATA for DRAFT VERSION of SPACE TEST 6/R.

(N = 78)

Row	S_1	S_2	S_3	S_4	S_5	S_6	Σ	E_{13}	Remarks
1.	-	-	-	-	10	8	-	-	Omit
	13	13	8	10	8	3	55	.58	-
	12	12	10	9	3	6	52	.58	-
	11	12	8	8	5	2	46	.62	-
	13	13	11	10	9	5	61	.46	-
2.	13	12	12	13	7	6	63	.46	-
	13	13	11	11	7	7	62	.46	-
	13	12	-	-	9	5	-	.42	Omit
	13	13	11	11	8	2	58	.62	-
	-	-	-	-	12	4	-	-	Omit
3.	-	-	-	-	13	6	-	-	Omit
	9	9	-	-	3	5	-	-	Omit
	11	13	11	11	5	0	51	.73	-
	11	12	10	11	8	0	52	.58	-
	11	13	11	13	11	1	60	.46	-
4.	13	13	12	13	6	5	60	.58	-
	13	13	13	10	5	1	55	.77	-
	12	10	12	10	4	1	49	.65	-
	12	11	-	-	8	4	-	.42	Omit
	12	13	12	13	8	3	61	.54	-
5.	12	9	-	-	7	5	-	-	Omit
	13	11	13	10	8	1	56	.54	-
	12	11	11	10	6	1	51	.62	-
	12	12	12	9	6	3	54	.58	-
	13	12	12	12	8	4	61	.50	-
6.	13	13	13	13	8	4	64	.54	-
	13	13	9	7	5	0	47	.81	-
	13	13	11	10	6	2	55	.69	-
	13	12	12	10	9	4	60	.46	-
	13	12	13	13	10	1	62	.54	-
7.	12	9	3	4	3	1	32	.65	-
	13	11	6	3	4	2	39	.69	-
	12	12	-	-	8	5	-	.42	Omit
	10	12	10	8	7	0	47	.58	-
	-	-	-	-	10	6	-	-	Omit
8.	12	13	12	12	8	5	62	.46	-
	10	7	6	4	1	2	30	.54	-
	10	11	10	10	5	2	48	.54	-
	11	9	11	9	4	2	46	.54	-
	-	-	-	-	10	5	-	-	Omit
9.	12	12	-	-	9	4	-	.42	Omit
	13	13	11	10	6	5	58	.58	-
	12	12	12	9	2	3	50	.73	-
	13	13	12	10	6	5	59	.58	-
	13	13	13	12	9	5	65	.46	-
10.	-	-	-	-	12	8	-	-	Omit
	10	9	-	-	5	6	-	-	Omit
	13	13	13	13	8	2	62	.62	-
	13	13	12	10	3	4	55	.73	-
	13	13	12	12	6	3	59	.65	-
11.	12	13	11	13	6	2	57	.65	-
	12	13	12	11	5	4	57	.62	-
	12	12	11	11	5	1	52	.69	-

Row	S_1	S_2	S_3	S_4	S_5	S_6	Σ	E_{13}	Remarks
	10	13	11	10	7	2	53	.54	—
	—	—	—	—	10	5	—	—	Omit
12.	13	10	7	6	2	3	41	.69	—
	13	13	13	13	9	1	62	.62	—
	13	12	12	13	9	2	61	.54	—
	13	12	12	12	10	2	61	.50	—
	13	13	13	13	11	2	65	.50	—
13.	13	13	13	12	7	6	64	.50	—
	13	10	9	4	2	2	40	.73	—
	13	12	13	8	7	1	54	.65	—
	13	13	11	10	8	3	58	.58	—
	13	13	13	8	7	3	57	.62	—
14.	13	13	13	13	10	3	65	.50	—
	13	10	7	4	2	1	37	.77	—
	13	12	9	9	5	4	52	.62	—
	13	13	13	10	7	5	61	.54	—
	13	13	13	12	10	3	64	.50	—
15.	—	—	—	—	8	8	—	—	Omit
	12	11	5	1	2	3	34	.69	—
	12	12	12	7	5	5	53	.54	—
	13	13	10	9	7	5	57	.54	—
	13	13	9	13	9	5	62	.46	—
16.	12	13	—	—	8	6	—	.42	Omit
	10	9	4	3	3	2	31	.54	—
	10	13	10	7	5	4	49	.54	—
	10	12	9	7	3	0	41	.73	—
	13	13	10	11	10	3	60	.50	—
17.	13	12	13	11	6	2	57	.65	—
	13	12	11	10	5	0	51	.77	—
	13	12	12	9	5	3	54	.65	—
	12	12	—	—	9	5	—	—	Omit
	12	12	11	10	7	1	53	.62	—
18.	13	11	5	6	2	5	42	.65	—
	11	13	9	10	3	2	48	.73	—
	13	13	11	9	4	0	50	.85	—
	12	12	10	7	6	1	48	.65	—
	12	12	—	—	8	5	—	.42	Omit